A MICROFAUNAL STUDY OF THE SHAFTESBURY FORMATION

A.R. NIELSEN

University of Alberta

Faculty of Arts and Science

Department of Geology

The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled "A Microfaunal Study of the Shaftesbury Formation" submitted by Arne Rudolph Nielsen, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

Professor

Professor

Professor

Date . . . . . .

THE UNIVERSITY OF ALBERTA

A MICROFAUNAL STUDY OF THE SHAFTESBURY FORMATION

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

FACULTY OF ARTS AND SCIENCE

by

ARNE RUDOLPH NIELSEN, B.Sc.

EDMONTON, ALBERTA

April 8, 1950

FRONTISPIECE

Smoky River Bank, near Judah, Alberta, (locality 16-47-29), showing Shaftesbury formation, shales below the siltstone member, 600' above the base.
Peace-Smoky River forks in background.


SILTSTONE MEMBER

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ABSTRACT

The foraminiferal species of the Cretaceous Lower Shaftesbury formation occur as two microfaunal assemblages, an upper Miliammina-Tritaxia fauna overlying a lower Gaudryina-Verneuilina fauna. The Miliammina-Tritaxia fauna occurs within the base of, and directly below a Holcolepis fish-scale zone within the Shaftesbury formation. The Gaudryina-Verneuilina fauna occurs below the Miliammina-Tritaxia fauna and above the contact of the Shaftesbury and Peace River formations. The upper fauna reflects a shallower facies than the lower fauna.

The term "Miliammina manitobensis fauna" is used to designate a microfaunal assemblage found between the Viking sand member and the fish-scale "sands" of the Lloydminster (Colorado) formation in Western Canada. This "Miliammina manitobensis fauna" corresponds to the Gaudryina-Verneuilina fauna of the Lower Shaftesbury formation. The fauna of the lower part of the Upper Ashville formation of Manitoba (the type horizon of Miliammina manitobensis) corresponds more closely to the Miliammina-Tritaxia fauna of the Shaftesbury formation.

Based on the Miliammina-Tritaxia and Gaudryina-Verneuilina faunas, the Lower Shaftesbury formation is correlated with the Upper Buckinghorse and the Sikanni sandstones of North-Eastern British Columbia; the Ashville formation of Manitoba; with that part of the Lloydminster (Colorado) shale, of the Central-Alberta area, between the Viking sand member and fish-scale sands and with the basal 150' feet of the Labiche formation of the Athabaska River area, Alberta.

Twenty-seven species of foraminifera are described and illustrated. These include the following ten genera: Ammobaculites (four species), Gaudryina (two species), Haplophragmoides (three species), Hyperammina (one species), Miliammina (six species), Nodosinella (one species), Proteonina (two species), Reophax (two species), Tritaxia (two species), and Verneuilina (four species).

A MICROFAUNAL STUDY OF THE SHAFTESBURY FORMATION

CHAPTER I

INTRODUCTION

PREFACE

Until recently, megafossils and lithologic association provided the only means of dating and correlating the extensive Western Canadian Cretaceous deposits. The scarcity of megafossils in many sections as well as the difficulty of obtaining recognizable megafossils from well cores has hampered the development of detailed correlations within the Cretaceous sequence of strata.

Published studies by Dr. R. T. Wickenden, Dr. J. A. Cushman, and Dr. A. W. Nauss and unpublished studies by Mr. C. R. Stelck and Mr. J. H. Wall open a new and promising field of study of the Western Canadian Cretaceous microfaunal suites that provides an accurate method of dating and correlating the outcropping Cretaceous strata in the Alberta foothills with the Cretaceous sequence underlying the Plains area of Western Canada.

In order to make a contribution to such a correlation the writer has undertaken a microfaunal study of the

Shaftesbury formation of the Cretaceous sequence in the Peace River area.

A group of foraminiferal suites prepared from collections from surface outcrops of the Shaftesbury formation in the Peace River area have been studied. The succession of foraminiferal assemblages in the Shaftesbury formation is here established, morphologic types are described and illustrated, and by comparison with previously established foraminiferal suites, the Shaftesbury formation is placed in its correlative stratigraphic position in the Cretaceous sequence of Western Canada on the basis of microfaunal evidence.

FIELD WORK

The shale samples of the Shaftesbury formation from which the foraminiferal suites for this study were obtained, were collected by an Imperial Oil surface party in the field season of 1947. This party consisted of C. R. Stelck, chief, J. H. Wall and H. W. Cummings, assistants. Samples of the Shaftesbury formation were collected from four different localities: along the Smoky River near Judah Station, along the Smoky River half a mile downstream from Judah Station, from an outcrop area near the Shaftesbury settlement, and from the north bank at the junction of the Peace and Smoky Rivers.

Stratigraphically, samples ranged from the underlying Peace River-Shaftesbury contact to 116' above a zone of fish-scales that occurs an estimated 250'-300' below the overlying Dunvegan Formation.

Collections from only one locality, the Shaftesbury settlement, were from type section of the Shaftesbury. These collections were not tied in with any known stratigraphic horizon. The other four collected sequences of samples were definitely located stratigraphically with respect to a gypsiferous sandstone bed used as a marker in the fish-scale zone or with an occurrence of Inoceramus cadottensis in the Peace River formation.

Continuity of vertical section in collecting was obtained by correlation of individual beds and by direct measurements of thicknesses of beds between sample points.

SAMPLING PROCEDURE

The samples were obtained by following a discontinuous sampling procedure. All samples were obtained from well-exposed shale banks along the Peace and Smoky Rivers. Samples were collected with stratigraphic intervals from 4 feet to 10 feet separating the sampled beds. A small pit was dug at each sampling point and

a 6-inch thickness of strata sampled. All sampling was done carefully by hand and all ironstone concretionary nodules and coarse sand elements were eliminated.

Samples were immediately placed in postal-type cotton bags and were shipped to the Imperial Oil Calgary Subsurface Department. A duplicate set of samples was sent to the Department of Geology, University of Alberta, Edmonton.

In the Imperial Oil Subsurface Department in Calgary, the samples were disintegrated, washed, screened, and picked for microfauna by experienced "pickers". Although no mechanical means of disintegration were used, recovery from the Shaftesbury samples was very poor. Of eighty-two samples picked, thirty-four (forty one per cent) were declared barren while from twenty-eight others less than twenty fossils per sample were obtained.

The microfaunal suites picked by Imperial Oil Company in Calgary were placed at the writer's disposal when he commenced his microfaunal study of the Shaftesbury formation at the Department of Geology, University of Alberta, in September, 1949. The writer personally disintegrated and picked the majority of the Shaftesbury samples, using the duplicate material in the University

of Alberta collections. The "barren" or "near barren" samples received the most concentrated attention. Very good results were obtained. Only eight samples were barren and these were from sandy phases above the fish-scale horizon or from sandy phases of the basal Shaftesbury near the contact with the Peace River formation. Many samples considered barren on the original Imperial Oil samples yielded more than one hundred foraminifera from the duplicate samples. The comparative results emphasize the advantage of an academic follow-up to commercial work. Picking of foraminifera is in itself a mechanical procedure but the results are better if the picker has a definite scientific interest in the sample. The procedure used by the writer is outlined in the following paragraphs.

Approximately one-quarter to one-half of the contents of each sample bag was placed in half-pint jars and covered with water. The samples were soaked an indefinite period of time until they had disintegrated sufficiently to be easily washed. No mechanical or chemical methods of disintegration were used resulting in a low percentage of broken microfossils.

When maceration was completed, the samples were carefully washed and screened through a set of standard

Tyler screens. A set of five individual screens of 28, 48, 80, 100, and 150 mesh to the inch was used with a collecting pan at the bottom. In washing the samples through the screens, a jet of water was directed on the screen and the shale sample was gently worked between the fingers until all clay had been removed. This procedure was repeated for each succeeding screen size and in each case the residue in the screen was transferred to a shallow saucer by directing a gentle stream of water on the underside of the screen. The residue in the pan was thoroughly washed and decanted until all fine clays had been removed and then it also was transferred to a shallow saucer. The residues in the saucers were dried at room temperatures.

The dry sample was then poured onto a tray of royal blue or light blue background in such a manner that a single layer of grains was formed and all grains showed up against the blue background. The bottom of the tray was divided into narrow zones equal in width to the width of the microscopic field. This allowed a systematic examination of all particles on the picking tray.

Picking was carried out under a model BKW-5 Bausch and Lomb binoculars using a Spencer 30 watt 10

volt light. Magnification of 30 power and 45 power were successively used.

A very fine, pointed, wetted, sable hair brush (No. 00.) was used to transfer the microfossil from the picking plate to the slide.

Ten-cell oil-field type slides were used for mounting. Mounting was done on a black mat-surface, prepared by applying a solution of gum-tragacanth, with a small content of formaldehyde to prevent moulding. The gum was placed directly on the slide and permitted to dry. When the microfossil is transferred from the picking plate on the wet sable brush, the moisture from the brush softens the gum sufficiently to permit the fossil to become attached to the slide. The gum, being transparent, does not mask the morphologic features of the microfossil.

Each individual sample was picked from eight per cent to one hundred per cent depending upon the frequency of occurrence of the foraminifera. As each size range was picked, the remainder was bottled in case further examination of the material was necessary. The coarsest size, after being picked, was discarded. If the pan residue yielded no result, it was also discarded.

Contamination of the samples was possible only during the washing process. The same set of screens were used by D. B. Bullock, doing a statistical analyses of the microfauna below and above the Viking sand, and by W. G. Bahan, working on microfaunal assemblages from the Cretaceous Athabasca River section. Although contamination from these sources was possible, it was very remote as all screens were thoroughly cleaned after each screening.

After picking of all samples was completed, a careful study of the microfauna indicated certain critical morphologic types suitable for illustrating and description. One particular specimen of each selected morphologic type is used as a hypotype and mounted in a single cell slide. Three other fossils of similar morphologic type as the hypotype are mounted with the hypotype to be used as paratypes to the hypotype. These types are filed in the University of Alberta Museum.

PHOTOGRAPHY PROCEDURE

Using a Leitz Wetzlar M4B camera and a Leitz Wetzlar No. 394712 microscope, micro-photographs were taken of all hypotypes. Magnifications of 45x and 95x

were used depending upon the size of the microfossil. The negatives were developed by the writer, using developing equipment and dark room facilities in the Department of Geology, University of Alberta. Prints of the negatives were made by a commercial firm. The photographs are re-touched in order to accentuate certain features not well defined in the original print. The photographs of the individual fossils are cut out and remounted on a black background, then re-photographed to produce the plates illustrated in this thesis.

PREVIOUS WORK

Only one reference has been published on the microfauna of the Fort St. John group of the Peace River area. R. T. D. Wickenden (ref. 78) in his discussion of the Cretaceous Ashville formation in Manitoba, mentions the occurrence of Haplophragmoides and Ammobaculites in the Fort St. John group, on which basis he suggests a possible lower Ashville-Shaftesbury correlation.

Published works on the foraminifera of Western Canadian Cretaceous by J. A. Cushman, R. T. D. Wickenden, and A. W. Nauss whose works appear in the bibliography, were used in this thesis for all named Canadian forms.

An unpublished report on the microfauna of the Fort St. John has been completed by C. R. Stelck. This work describes many new Western Canadian Cretaceous foraminifera, mainly from the Fort St. John group, establishes the Albian-Cenomanian contact throughout Western Canada, and correlates various Western Canadian Cretaceous sections. The microfauna from the Shaftesbury type area is not described in Stelck's report but many Shaftesbury forms are found to be common with the faunas he describes.

ACKNOWLEDGEMENTS

The writer acknowledges the encouragement and the generous assistance accorded to him by Dr. P. S. Warren, Dr. R. L. Rutherford, Dr. R. E. Folinsbee, and Mr. C. R. Stelck of the Department of Geology, University of Alberta.

The writer received the utmost help from all members of the Department of Geology, not only throughout the writing of this thesis but throughout his undergraduate years.

Dr. P. S. Warren gave valuable advice with respect to the original choice of thesis.

Dr. R. E. Folinsbee aided in the setting up of the photographic and developing equipment and rendered

advice on the photographic and developing procedure.

The writer is deeply indebted to Mr. C. R. Stelck under whose direct supervision this thesis was written. Mr. Stelck performed the basic field work and supplied the original material for this thesis. He has accorded continuous assistance in the preparation of the microfaunal suites, selection of hypotypes, and final preparation of the photographs. Mr. Stelck's knowledge of the stratigraphy and paleontology of the Cretaceous of Western Canada has permitted the writer to concentrate his energies on the Shaftesbury microfauna. The writer has had access at all times to the manuscript of Mr. Stelck's thesis on the Albian-Cenomanian Foraminifera of Western Canada.

CHAPTER II

THE SHAFTESBURY FORMATION

INTRODUCTION

The Shaftesbury formation is a shale formation of the Cretaceous Fort St. John group of Western Canada. The type section of the Shaftesbury formation outcrops in the Eastern Peace River area of Alberta near the town of Peace River.

The writer has examined the Fort St. John shale in the A La Peche Map Area, Alberta (ref. 33, pp. 14) but is not familiar with outcrops of the Fort St. John group in the Peace River area. The description of the Shaftesbury formation, its lithology, thickness, extent, and megafauna is extracted from published and unpublished reports by other workers.

Microfaunal studies by the writer involving shale samples from which the foraminiferal suites were picked reveals the general lithology of the formation. However, these samples do not give an accurate picture of the lithology as in sampling, coarser sand elements and ironstone nodules are eliminated in order that the samples might give as high a recovery of foraminifera as possible. A detailed lithologic succession of the

strata from which the foraminiferal suites were obtained is included in the Appendix.

In the following chapter the writer discusses the development of the knowledge of the Fort St. John group from the earliest exploration trips up to the definition of the Shaftesbury formation by McLearn in 1944. The extent, thickness, and megafauna of the Shaftesbury formation is also discussed.

EARLY WORK

The first white man known to have visited the Peace River area was Sir Alexander Mackenzie in 1792. Mackenzie, on his famous exploration trip to the Pacific Coast, established a temporary fort at the junction of the Peace and Smoky rivers, where he wintered in 1792-93. The following summer, Mackenzie ascended the Peace and Parsnip rivers, portaged over the continental divide to tributaries of the Fraser river, and then downstream to the Pacific Ocean.

The first geologist to visit the Peace River area was A. R. C. Selwyn of the Geological Survey of Canada, who in 1875 spent the field season doing reconnaissance geology in the Peace and Pine river areas. From Selwyn's geological observations we obtain the first

descriptions of what is now called the Shaftesbury formation. (Ref. 64, pp. 72.)

"From 'The Fork' - Smoky River- up to Dunvegan and thence to about five miles below Hudson Hope, the rocks which are exposed along Peace River consist of dark, earthy shales, in parts characterized by numerous bands and septarian nodules of clay ironstone, many of which enclose large ammonites and they are also associated with sandy calcareous layers holding other Cretaceous fossils, among which a species of inoceramus is tolerably abundant, while in the dark argillaceous shales, the scales of fish are frequently observed."

G. M. Dawson visited the Peace River area in 1879 and carried out the first detailed geological exploration of the area. Based on his observations of the rock sections on Pine and Smoky rivers and on the descriptions given by Selwyn of the rocks of the Peace River, Dawson made the first subdivision of the Cretaceous rocks of the Peace River area and in 1893 published the following table of formations (ref. 17, pp. 115):

1. Upper sandstones and shales with lignite coals (Wapiti river sandstone)

2. Upper dark shales (Smoky river shales)

3. Lower sandstones and shales with lignite and true coals (Dunvegan sandstone)

4. Lower dark shales (Fort St. John shales)

Thus, Dawson first named the Fort St. John formation, defining it as those marine shales occurring below the Dunvegan formation.

In 1888 R. G. McConnell carried out further geological exploration in the Peace and Smoky river areas. McConnell elaborated on Dawson's original Cretaceous subdivision and in 1893 published the following table of formations (ref. 39, pp. 53D):

Wapiti River sandstones

Foxhill sandstone

Smoky River shales

Dunvegan sandstone

Fort St. John shales

Peace River sandstones

Loon River shales

Thus, McConnell further delimited the Fort St. John shale by placing its lower contact at the upper sandstone member of a series of sandstones and shales which he named the Peace River sandstones.

McConnell examined the Fort St. John shale in outcrop along the Peace River from the Smoky River forks northward and described the formation as consisting

of brownish, greyish and black shales with numerous ironstone nodules and containing fish-scales.

The next important work that was carried out in the Peace River area was by F. H. McLearn who made a series of field trips to the area in 1917, 1918, 1920, and 1922 (ref. 41, 42, 45, 46). As a result of extensive geological work along both Peace and Smoky rivers, F. H. McLearn in 1918 published the following table of formations (ref. 42, pp. 2c):

<table>
<tr><th colspan="2">System</th><th>Group</th><th colspan="2">Smoky-Peace Section</th></tr>
<tr><td rowspan="7">Cretaceous</td><td rowspan="5">Upper</td><td rowspan="2">Montana</td><td colspan="2">Wapiti</td></tr>
<tr><td>Upper Shale</td><td rowspan="3">Smoky River</td></tr>
<tr><td rowspan="3">Colorado</td><td>Bad Heart Sandstone</td></tr>
<tr><td>Lower Shale</td></tr>
<tr><td colspan="2">Dunvegan</td></tr>
<tr><td colspan="2">St. John</td></tr>
<tr><td rowspan="4">Lower</td><td rowspan="4">"Lower Cretaceous"</td><td>Upper Sandstone</td><td rowspan="3">Peace River</td></tr>
<tr><td>Middle Shale</td></tr>
<tr><td>Lower Sandstone</td></tr>
<tr><td colspan="2">Loon River</td></tr>
</table>

In his report, McLearn shortened the name of the formation from Fort St. John to St. John. In this connection it is pointed out that there already existed the name "St. John" for a Middle Cambrian formation in New Brunswick.

McLearn discussed the lithology of the Fort St. John formation as follows (ref. 42, pp. 3c):

"The St. John consists principally of dark, friable, and paper thin carbonaceous shale with some ironstone bands and concretions; where the bedding shows it is on a scale of about two inches and indicates marine conditions. The top of this formation consists of thin-bedded sandstone and shale which in places, by increase in thickness of the sandstone layers upwards, shows a gradation into the massive sandstone at the base of the Dunvegan. The thickness is 560' (est.)."

In the years 1919-1922, other geologists added considerably to our knowledge of the Peace River area. M. Y. Williams (ref. 81), J. S. Stewart (ref. 68), J. A. Dresser (ref. 22, 23), J. C. Gwillim (ref. 28), and E. M. Spieker (ref. 65, 66), the latter three working for the Department of Lands, British Columbia, all carried out surveys in the Peace River area but introduced few new terms.

FIGURE I.

Smoky River Bank, near Judah, Alberta, (locality 16-47-30), showing Shaftesbury formation, shales above the siltstone member.

FIGURE II.

Smoky River Bank, downstream from Judah, Alberta (locality 16-47-31), showing lower part of Shaftesbury formation.

J. A. Allan (ref. 1) of the Research Council of Alberta, first visited the Peace River area in 1921 and followed this with several other visits in later years.

In 1929 R. L. Rutherford (ref. 63) carried out a survey of the underground water resources in the Peace River area. The report published in 1930 included a geological map of the area. Rutherford studied the "St. John" formation at Judah and at the Shaftesbury settlement, the same outcroppings from which the foraminiferal suites used in this thesis were obtained. Rutherford describes (ref. 63, pp. 17) the "St. John" formation as dark to grey shales, thin bedded, with ironstone nodules and concretions. He estimates the thickness of the "St. John" formation as approximately 600'. Rutherford uses the following terminology in describing the Cretaceous section in the eastern Peace River area:

Upper Smoky River shale
Bad Heart Sandstone
Lower Smoky River shale
Dunvegan formation
St. John formation
Peace River formation

In 1931 L. S. Russell (ref. 62) of the G. S. C.

carried out a survey of the eastern Peace River area. Although a preliminary map of the area (Sexsmith-Bison Lake) was published, it was not accompanied by a report. The terminology used on the map was:

Upper Cretaceous

Wapiti formation

Dark marine shale)

Bad Heart formation) Smoky group

Kaskapau formation)

Dunvegan formation

Lower Cretaceous

Fort St. John formation

Peace River formation

Loon formation

Thus, Russell re-introduced the term "Fort St. John" for that formation of marine shales occurring between the Dunvegan and Peace River formations.

DEFINITION OF THE SHAFTESBURY FORMATION

In 1942 Wickenden and Shaw in reporting on the geology of the Commotion Creek Map Area, Alberta, raised the Fort St. John from formation to group rank to include the following formations (ref. 77, pp. 3):

Cruiser formation

Goodrich formation

Hasler formation

Commotion formation

Moosebar formation

In 1942, McLearn and Henderson (ref. 55) mapped the Lone Mountain Area, British Columbia. In the Fort St. John group they placed two formations a lower sandstone and conglomerate and an upper dark marine shale.

In the published report on the area, McLearn and Henderson brought the formational name "Shaftesbury" into being with the following statement (ref. 55, pp. 3):

"The name 'Shaftesbury' is herewith proposed for the formation lying between the Peace River and Dunvegan formations in the eastern part of the Peace River district. The type area is along Peace River Valley between the town of Dunvegan and the town of Peace River. The shales of this formation were formerly included in the Fort St. John formation."

McLearn and Henderson suggested a correlation between the dark marine shale of the Lone Mountain area with the type Shaftesbury of the Sexsmith-Bison Lake Map Area.

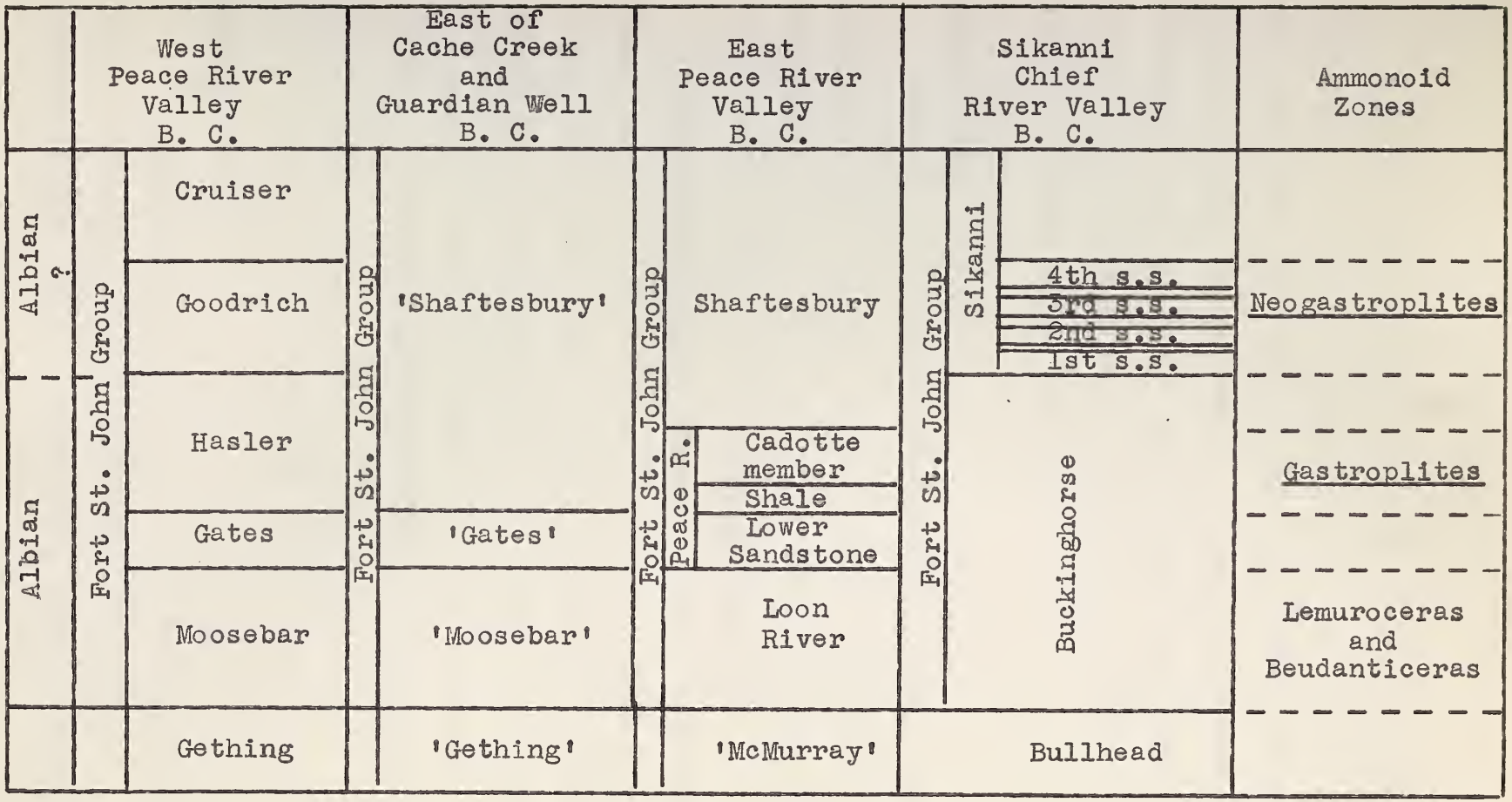


Figure III. Correlation Chart of the Lower Cretaceous sections of the Peace River area - McLearn.

The Fort St. John group of the eastern part of the Peace River valley was later defined by McLearn (ref. 58, pp. 4) to include the Loon River, Peace River, and Shaftesbury formations. The various formations included in the Fort St. John group in different parts of the Peace River area as presented by McLearn (ref. 58, figs. 1, 2) are as on page 21.

PALEONTOLOGY

Correlations of the Shaftesbury formation are based primarily on the occurrence of a fauna in the Shaftesbury of the Fort St. John area, British Columbia, carrying the ammonite genus Neogastroplites.

The Neogastroplites fauna was first collected by Selwyn (ref. 64, pp. 72) on his early exploration trip to the Peace River area. Selwyn collected several ammonites and pelecypods and also noted the numerous fish-scales within the formation. The ammonites collected by Selwyn were described as Buchiceras cornutum by Whiteaves (ref. 74). McLearn (ref. 49, pp. 7) later used this species as the genotype of Neogastroplites.

The Neogastroplites fauna collected by Selwyn included Neogastroplites cornutus (Whiteaves), Neogastroplites selwyni (Whiteaves), Nucula dowlingi

(McLearn), and Posidonia nahwisi (McLearn). This fauna was collected from the north bank of the Peace River between Cache Creek and Fort St. John. Since then, the Neogastroplites fauna has been collected from several sections in the Peace River area. A fragment of an ammonite found in the upper dark marine shale in the Lone Mountain area was tentatively identified by McLearn as Neogastroplites cornutus (Whiteaves). Stelck has collected Neogastroplites sp. and Posidonia nahwisi from marine shales regarded as the equivalent of the Shaftesbury formation in the Wapiti river area, Alberta and British Columbia and in the Kakwa-Upper Copton area, Alberta. Neogastroplites has been collected from the Goodrich formation in the Pine River area and from the Sikanni sandstones in the Sikanni River area. These specimens are present in the University of Alberta paleontological collections. Neogastroplites has not to date (1950) been reported from the Shaftesbury type section in the east Peace River area.

Where Neogastroplites has been collected from the Shaftesbury formation in the upper Peace River area, it occurs below and within the base of a fish-scale zone (ref. 2a). The scales of a species of

Holcolepis dominates the fauna of the fish-scale zone. This fish-scale zone is very persistent throughout the Fort St. John group in the eastern Peace River area and all workers since Selwyn have noticed and commented on this marker horizon. Although Neogastroplites does not occur everywhere in the Shaftesbury formation, the lower part of the Holcolepis fish-scale zone may be considered representative of the Neogastroplites fauna. Both McLearn (ref. 58, pp. 11) and Stelck (ref. 2a) have dated the Neogastroplites fauna as Late Albian in age.

In the eastern Peace River area no megafauna older than the Neogastroplites fauna occurs within the Shaftesbury formation, - a Gastroplites fauna occurs in the second sandstone from the top in the Peace River formation. In the western Peace River area, Gastroplites occurs in the lower part of the "Upper Fort St. John shales" (Shaftesbury) and thus places the lower part of the Shaftesbury in this area in the upper Middle Albian stage (Stelck, pers. comm.).

LITHOLOGY

A detailed description of the lithology of the sections of the Shaftesbury formation from which the

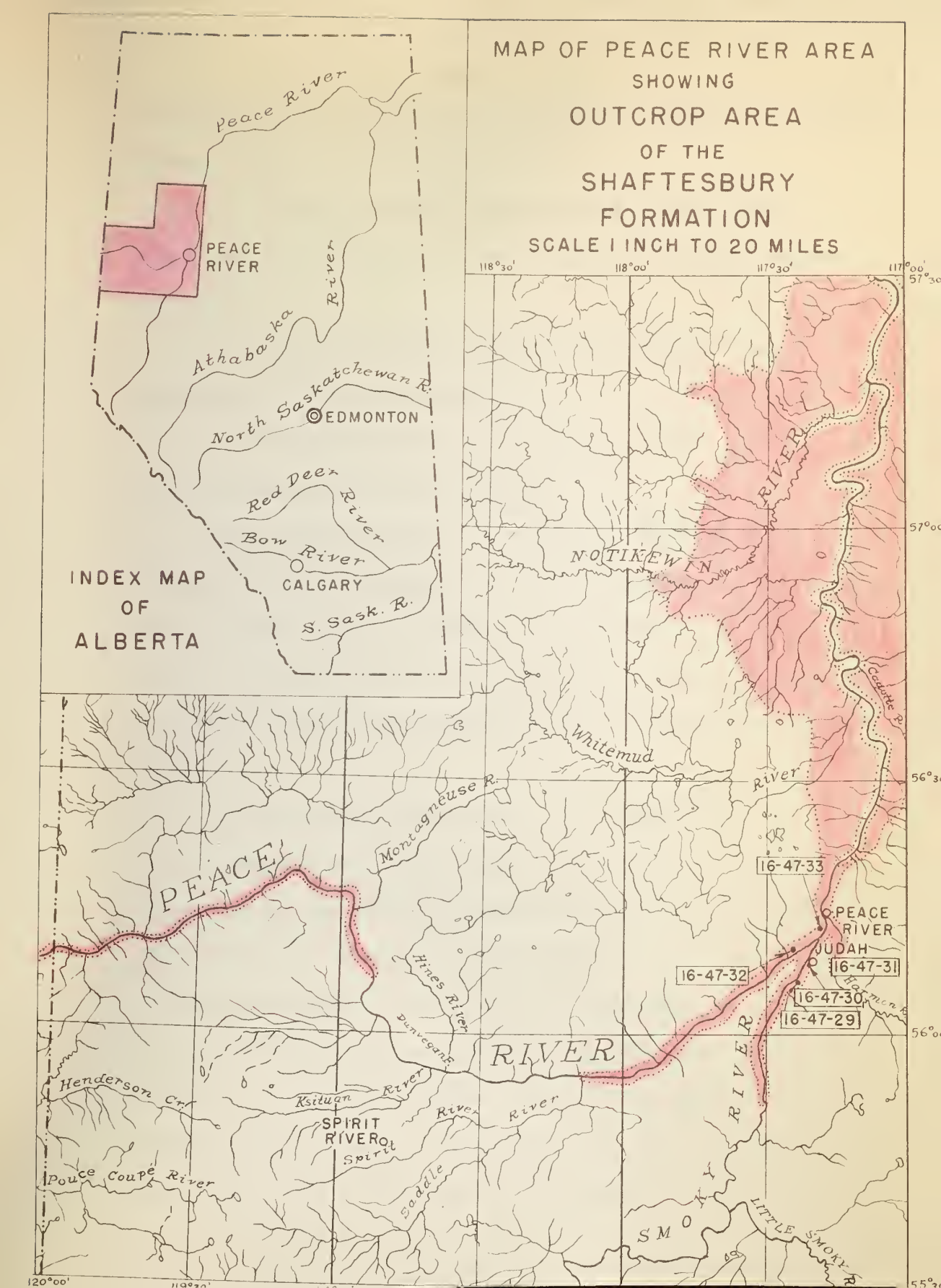
shale samples were collected is included in the Appendix to this thesis.

In the eastern Peace River area the Shaftesbury formation is composed of dark grey to brownish, fissile shales of varying siltiness. These shales are marine and for the most part finely laminated. Some narrow bands and lenticles of siltstones occur interbedded with the shales, the majority of the siltstone bands containing buff ironstone concretions.

The Shaftesbury formation is conformable with both the overlying Dunvegan formation and the underlying Peace River formation. The Shaftesbury-Peace River contact is relatively abrupt with the massive, crossbedded, argillaceous sandstone of the Peace River formation grading rapidly upwards into the silty shales of the Shaftesbury formation. The Shaftesbury-Dunvegan contact is very gradational and extremely difficult to define. The contact is placed at the base of the first massive sandstone member of the Dunvegan.

EXTENT AND THICKNESS

Throughout the Peace River area, the Shaftesbury formation outcrops principally along the banks of the major streams. In the eastern Peace River area the


MAP OF PEACE RIVER AREA
SHOWING
OUTCROP AREA
OF THE
SHAFTESBURY
FORMATION
SCALE 1 INCH TO 20 MILES
INDEX MAP
OF
ALBERTA
Peace River
PEACE
RIVER
Athabaska River
North Saskatchewan R.
EDMONTON
Red Deer River
Bow River
CALGARY
S. Sask. R.
118°30'
118°00'
117°30'
117°00'
57°30
57°00
56°30
56°00
55°30
NOTIKEWIN
RIVER
Whitemud
River
Montagneuse R.
PEACE
RIVER
Hines River
Dunvegan
RIVER
Henderson Cr.
Ksituan River
SPIRIT
RIVER
Spirit
River
Saddle
River
Pouce Coupé River
SMOKY
RIVER
LITTLE SMOKY
16-47-33
PEACE
RIVER
JUDAH
16-47-31
16-47-32
16-47-30
16-47-29
120°00'
119°30'

outcrops of the Shaftesbury may be divided into three sectors (see accompanying map):

1. From the Smoky River-Peace River forks upstream on the Peace River towards Dunvegan (type section).

2. From the Smoky River-Peace River forks upstream on the Smoky River.

3. From the Smoky River-Peace River forks downstream on the Peace River.

The type section of the Shaftesbury formation extends westward along the Peace River from the Smoky River forks to the mouths of the Saddle and Burnt Rivers. However no more than 50' of the formation is exposed. The upper contact only is observed in this section.

On the Smoky River above the forks, the Shaftesbury formation extends upstream to within two miles of Racing Creek (approximately 25 miles where it disappears below the water level). It is overlain by the Dunvegan. Some good sections are exposed along the Smoky River although no complete section occurs. In spite of this lack of a complete section McLearn (ref. 42, pp. 3c) estimates the thickness of the "St. John" formation on the Smoky as 560' and

Rutherford (ref. 63, pp. 17) estimates the thickness at Judah as 600'.

Below the Peace River-Smoky River forks, the Shaftesbury formation is exposed in the banks of the Peace River to beyond the Battle River. It overlies the Peace River formation which is exposed at the water's edge. McLearn estimates a minimum thickness of 700' in this area.

Ascending the Peace River from Dunvegan, the Shaftesbury formation (Upper St. John shales) appears above the water level and underlying the Dunvegan about twelve miles below the Montagneuse River. From there the Shaftesbury formation outcrops intermittently in the Peace River valley into British Columbia almost to Hudson Hope. West of Cache Creek, the Shaftesbury formation overlies the Gates formation.

In the western Peace River area the Shaftesbury formation shows a definite increase in thickness. Dawson (ref. 17, pp. 116B) reports 600' exposed a mile below Fort St. John, and McLearn (ref. 41, pp. 17c) estimates a total thickness of the Shaftesbury formation of 1300' in the vicinity of Cache Creek.

The thickening of the Shaftesbury formation to

the west is also indicated south of the Peace River where Allan and Stelck (ref. 5, pp. 17) report 642' of St. John (Shaftesbury) formation in the Guardian Well #1, and Wickenden and Shaw (ref. 77, pp. 2) estimate 2150'-2700' of Shaftesbury equivalent on Commotion Creek.

Three hundred miles to the southwest of type Shaftesbury area, Stelck has measured 2200' of Shaftesbury equivalent in the Wapiti River area and 1145' in the Kakwa River area. Irish (ref. 34, pp. 17, 35, pp. 14) reports only 400' of Fort St. John shales in the A La Peche and Moon Creek Map Areas.

Much field work remains to be done before the extent of the Shaftesbury formation in Northeastern British Columbia and Northwestern Alberta can definitely be determined. The intensified oil drilling program in the Peace River area will provide much valuable information in this respect. However all the evidence at present seems to indicate that the Shaftesbury formation and its marine shale equivalents form a continuous sheet of marine shales extending to the north, south, east and west of the Shaftesbury type area. Considerable thickening to the west and southwest occurs but that the formation

eventually pinches out to the south is indicated as Lang (ref. 36) did not find any Fort St. John shales on the Athabaska River.

The Shaftesbury sea was a vast boreal sea extending down from the north and covering Northeastern British Columbia and Northern Alberta almost to the present position of the Athabaska River. Thus the fauna from the Peace-Smoky Rivers area with which this thesis deals should not be a shoreline or near-shore fauna.

CHAPTER III

PALEONTOLOGY AND CORRELATION

MICROFAUNAL SUITES OF THE SHAFTESBURY FORMATION

Two distinct microfaunal assemblages are recognizable between the Holcolepis fish-scale zone and the base of the Shaftesbury formation. The upper one the writer has designated the Miliammina-Tritaxia fauna and the lower one the Gaudryina-Verneuilina fauna.

The Gaudryina-Verneuilina fauna

The lower distinct microfaunal assemblage occurs about 150' below the fish-scale marker-bed and about 100' above the top of the Peace River sandstone (locality 16-47-31). This fauna includes the following species:

Ammobaculites 31-246-A

Ammobaculites 31-290-D

Ammobaculites 32-20-A

Ammobaculites sp. (8-24E; Stelck MSS.)

Gaudryina 31-230-A

Gaudryina 31-258-A

Haplophragmoides 31-286-B

Haplophragmoides 31-290-C

Haplophragmoides sp. (8-304-E; Stelck MSS.)

Hyperammina 31-280-A

Miliammina 31-286-A

Miliammina 32-14-B

Nodosinella 31-290-B

Proteonina 31-290-A

Proteonina 30-142-A

Reophax 31-194-A

Reophax 31-211-B

Tritaxia 31-274-A

Verneuilina? 31-246-B

Verneuilina? 31-258-A

Verneuilina 31-211-A

Verneuilina? sp. (8-272-E; Stelck MSS.)

The above fauna is partially illustrated on Plates I and II of this thesis.

This fauna is essentially a shallow-water fauna and has several coarse grained forms (i.e. Proteonina). It is characterized by the large number of Gaudryina and Verneuilina which seem to dominate the assemblage. Especially distinctive are the varieties of Verneuilina? (31-246-B; 31-258-A; 8-272-E) which exhibit a quadriserial arrangement in the later chambers and a robust species of Verneuilina (31-211-A) with a close relationship to Verneuilina canadensis Cushman.

Coarse-grained species of Reophax and Proteonina are also common in this faunal assemblage.

Two species, widely different from any previously described from the Cretaceous of Western Canada, are common to the lower part of this faunal assemblage. They are Tritaxia 31-274-A and Nodosinella 31-290-B.

Miliammina are found sporadically throughout this faunal zone but in fewer numbers than in higher faunal zones. No species identical with Miliammina manitobensis Wickenden, as originally described and illustrated by Wickenden (ref. 75, p. 48) from the Ashville beds in Manitoba, has been identified in this zone. However, Miliammina 32-14-B shows some relationship with Miliammina manitobensis and an unfigured Miliammina from suite 16-47-31-258 shows even closer relationships to Miliammina manitobensis.

Species of Ammobaculites and Haplophragmoides are common throughout this microfaunal assemblage. Most species of both genera are crushed. Undistorted specimens of Ammobaculites (31-246-A; 31-290-D; 32-20-A) are somewhat similar to Ammobaculites tyrrelli Nauss, and occur frequently, especially in the lower part of the section.

The Miliammina-Tritaxia fauna

The lower Gaudryina-Verneuilina microfaunal assemblage grades upward into the distinctive Miliammina-Tritaxia fauna. This upper fauna is found within the base of and directly below the Holcolepis fish-scale zone. Species included in this fauna are:

Miliammina 30-4-A

Miliammina 30-31-A

Miliammina 30-68-A

Miliammina 30-147-A

Miliammina 30-129-A

Miliammina sp. (13-160-C; Stelck MSS.)

Miliammina sp. (13-170-C; Stelck MSS.)

Proteonina 30-142-A

Tritaxia manitobensis Wickenden, 1932

(30-26-A)

Verneuilina 30-147-B

This fauna is partially illustrated on Plates I and II of this thesis.

This microfaunal assemblage is dominated by various species of Miliammina. The more distinctive species are illustrated. Only two species, Miliammina 30-4-A and Miliammina 32-14-B carry over from the lower fauna but reach their maximum development directly below the fish-scale zone.

No species identical to Miliammina manitobensis has been found. However, some species (32-14-B; 30-4-A) show relationships to Miliammina manitobensis.

Tritaxia manitobensis Wickenden, 1932, is prevalent throughout this upper assemblage.

Only one species of Verneuilina (30-147-B) persists into the Miliammina-Tritaxia zone, the quadriserial Verneuilinas and the robust Verneuilinas are not found and the Gaudryinas have almost disappeared.

Fossil recovery from parts of the section immediately below the siltstone marker horizon of the fish-scale zone is very poor. These conditions persist above the siltstone marker into the Upper Shaftesbury formation. A few depauperate Miliammina are the only microfossils obtained from the section above the siltstone marker horizon (suite 16-47-29) and the fish-scale beds might well be included as the upper part of the Miliammina-Tritaxia zone.

Other Lower Shaftesbury faunas

The microfaunal suite collected from the outcrops along the Peace River at Shaftesbury settlement (suite 16-47-32) shows many elements common with the Gaudryina-Verneuilina fauna.

The following species, found in the Gaudryina-Verneuilina fauna (suite 16-47-31) are common to the type-Shaftesbury fauna:

Ammobaculites 31-290-D

Ammobaculites 32-20-A

Tritaxia 31-274-A

Hyperammina 31-280-A

Haplophragmoides 31-286-B

Miliammina 32-14-A

Nodosinella 31-290-B

The following additional forms also occur in the type Shaftesbury microfauna:

Haplophragmoides linki Nauss, 1947

Haplophragmoides sp.

Ammobaculites sp.

Verneuilina sp.

Haplophragmoides linki does not occur in the Verneuilina-Gaudryina fauna although a species of Haplophragmoides similar to it is found.

Numerous coarse-grained flattened Ammobaculites and flattened Haplophragmoides, similar to unillustrated species of the Gaudryina-Verneuilina fauna, are found in the type Shaftesbury assemblages.

Short, unflattened specimens of Verneuilina, somewhat similar to Verneuilina 31-246-B and Verneuilina 31-258-A are common.

The type Shaftesbury microfauna is slightly older than the fauna described from locality 16-47-31 but belongs to the Gaudryina-Verneuilina fauna.

A microfaunal suite collected from the basal Shaftesbury formation at the mouth of Strong Creek directly above the Peace River-Shaftesbury contact yielded no additional species to those discussed above. The species of the basal Shaftesbury are coarsely arenaceous Ammobaculites and Haplophragmoides. These forms are very similar to species found in the Gaudryina-Verneuilina assemblages even though Verneuilinas and Gaudryinas are not present in the basal suites. Evidence does not justify the separation out of a distinctive zone so the writer includes the basal Shaftesbury microfauna in the Gaudryina-Verneuilina zone.

THE MILIAMMINA MANITOBENSIS FAUNA

Miliammina manitobensis was originally described by Wickenden (ref. 75, p.90)from the "Upper

Cretaceous" Ashville formation of Manitoba. In his study of the Mesozoic stratigraphy of Manitoba (ref. 78, p. 23) Wickenden describes two foraminiferal faunas, one from the Upper Ashville formation and one from the Lower Ashville formation. The Upper Ashville microfauna is described as containing the two new species, Miliammina manitobensis and Tritaxia manitobensis as well as several unnamed species. The Lower Ashville microfauna, according to Wickenden, includes unnamed species of Ammobaculites and Haplophragmoides very similar to forms found in the Fort St. John Group in the Peace River District. On this basis Wickenden suggests a possible correlation between the Lower Ashville formation and the Shaftesbury formation. Wickenden places the Lower-Upper Cretaceous boundary within the Ashville formation but below the Miliammina manitobensis and Tritaxia manitobensis fauna.

Wickenden has identified Miliammina manitobensis in the Athabaska River area (ref. 80, p. 12) from the Colorado formation (Labiche shale) immediately above the Pelican sandstone and also from the Joli Fou formation below the Viking sand.

Stelck (ref. 2A, pp. 32) lists a fauna which he

calls the Miliammina manitobensis fauna, found close above the Viking sand member of the Lloydminster shale and containing the following species:

Ammobaculites coprolithiformis (Schwager)
Miliammina manitobensis
Gaudryina hectori
Verneuilina canadensis
Haplophragmoides c.f. excavata
Ammobaculites sp.
Gaudryina sp.
Reophax sp.
Holcolepis sp. (fish-scale)

In addition to the occurrences mentioned, the Miliammina manitobensis fauna has been recognized from above the Viking sand in the Viking-Kinsella gas field, Leduc oil field (ref. 37, p. 580) and in the area northwest of Edmonton.

In the Sikanni Chief River Area, Stelck, although recognizing a fauna similar to the Miliammina manitobensis fauna has not identified Miliammina manitobensis itself. The species most closely resembling Miliammina manitobensis is a Cenomanian form from the top of the Shaftesbury formation from the mouth of the Alces River, British Columbia.

The writer, in his studies of the Shaftesbury microfaunas has identified many of the elements of the Miliammina manitobensis fauna but has not recognized Miliammina manitobensis itself. As has already been pointed out, several Miliammina showing close relationships with Miliammina manitobensis are found.

Although elements of the so-called Miliammina manitobensis fauna of Alberta can be recognized in the Shaftesbury microfauna, the writer has hesitated to use the term in this thesis because:

1. Miliammina manitobensis has not been identified in the Shaftesbury microfauna.
2. There is some doubt that the Miliammina manitobensis fauna described by Wickenden from Manitoba is the same fauna as the one designated the Miliammina manitobensis fauna in Alberta.

The Lower Shaftesbury microfauna contains many elements in common with the Miliammina manitobensis fauna of Alberta. The upper part is dominated by Tritaxia manitobensis and Miliammina. The lower portion is the Gaudryina-Verneuilina fauna, is composed of several genera, and provides a more

efficient suite for correlation.

CORRELATION OF THE SHAFTESBURY MICROFAUNAL ASSEMBLAGES

Correlation with North-Eastern British Columbia

The Shaftesbury microfaunal assemblages may readily be correlated with the Lower Cretaceous microfaunal suites from the Sikanni Chief River Area, British Columbia.

The microfaunal suites of the Upper Buckinghorse formation contain many species identical or similar to the lower microfauna of the lower part of the Shaftesbury formation. The following species are common to both the Buckinghorse microfaunal suites and the lower microfauna of the Shaftesbury formation. These species, listed below, although not always identical, showed marked similarity.

Buckinghorse formation	Shaftesbury formation
Miliammina 8-290-A	Miliammina 32-14-B
Proteonina 8-148-A)	Proteonina 31-290-A
Proteonina 8-304-D)	
Proteonina 8-272-C	Reophax 31-211-B
Verneuilina 8-266-A	Verneuilina 31-211-A
Verneuilina? 8-227-A	Verneuilina? 31-246-B
Verneuilina? 8-304-E	Verneuilina? 31-258-A
Trochaminna 8-284-B	Trochaminna sp.

Buckinghorse formation (continued)	Shaftesbury formation (continued)
Ammobaculites 8-24E	Ammobaculites sp. (8-24E)
Haplophragmoides 8-304-B	Haplophragmoides sp. (8-304-B)
Verneuilina? 8-272-E	Verneuilina? sp. (8-272-E)

The above list includes only described forms but many undescribed additional forms are also common to both.

The following paired species are common to the shales between the second and third Sikanni sandstones and the upper fauna (Miliammina-Tritaxia fauna) of the lower part of the Shaftesbury formation.

Sikanni formation	Shaftesbury formation
Miliammina 13-160-C	Miliammina sp. (13-160-C)
Miliammina 13-170-C	Miliammina 30-4-A

Two species in the upper fauna of the Shaftesbury formation, Proteonina 30-142-A and Verneuilina 30-147-B, have comparative species in the Upper Buckinghorse formation.

On the microfaunal evidence presented above, the basal part of the Shaftesbury formation is correlated with the upper part of the Buckinghorse formation and that portion of the Shaftesbury formation directly below the fish-scale marker horizon may be correlated

with the shales between the second and third Sikanni sandstones.

Correlation with Manitoba

Wickenden identified three distinct faunas in the Ashville formation of Manitoba. The Lower Ashville microfauna contains species similar to those of the Shaftesbury formation of the Peace River area (ref. 78, p. 22). The Upper Ashville microfauna contains Miliammina manitobensis and Tritaxia manitobensis. The uppermost Ashville fauna is similar to that of the Dunvegan formation.

Tritaxia manitobensis and a Miliammina species similar to Miliammina manitobensis occur directly beneath the fish-scale zone of the Shaftesbury formation. The above microfaunal evidence indicates that the lower part of the Upper Ashville formation can be correlated with that part of the Shaftesbury formation immediately below the fish-scale zone. Megafossil evidence indicates that the uppermost part of the Ashville formation is of Dunvegan age.

Correlation with Vermilion Area, Alberta

Three faunal assemblages occur in the lower part of the Lloydminster shale of the Vermilion area (ref. 61, p. 331). The lowest assemblage, the

Haplophragmoides gigas fauna, occurs in the basal Lloydminster shale. Elsewhere, this fauna normally occurs below the Viking sand member. Above the Haplophragmoides gigas fauna occurs the "Miliammina manitobensis" fauna which elsewhere normally occurs above the Viking sand member. The Globigerina loetterli fauna is found toward the top of the Lloydminster formation about the horizon of the second white specks.

The "Miliammina manitobensis" fauna includes species very similar to the Shaftesbury microfaunal suites. Miliammina manitobensis and Tritaxia sp. found in this zone may be correlated with the Miliammina-Tritaxia zone of the Shaftesbury formation. Slightly lower, stratigraphically, in the Lloydminster shale are found Haplophragmoides linki, Haplophragmoides excavata, Ammobaculites fragmentaria and Ammobaculites tyrrelli. Haplophragmoides linki also occurs in the lower microfauna of the Shaftesbury formation and species similar to Ammobaculites fragmentaria and Ammobaculites tyrrelli are also found.

Thus, that part of the Shaftesbury formation below the fish-scale zone of the Lower Cretaceous

of the Peace River Area may be correlated with that part of the Lloydminster shale above the Haplophragmoides gigas fauna and below the Globigerina loetterli zone.

Correlation with Leduc Oil Field, Alberta

In the Leduc Oil Field, the Colorado group of marine beds have been divided into the following four members in descending order (ref. 37, p. 578):

Upper shale

Middle shale

Viking member

Lower shale

The following foraminifera have been identified in the Middle shale member (ref. 37, p. 580):

Ammobaculites fragmentaria Cushman

Ammobaculites tyrrelli Nauss

Miliammina manitobensis Wickenden

Miliammina sproulei Nauss

Verneuilina canadensis Cushman

Ammobaculites

Haplophragmoides

Verneuilina

Except for Miliammina sproulei, this fauna is similar to the Lower Shaftesbury fauna. On this

evidence part of the lower Shaftesbury formation may be correlated with that portion of the Colorado shale overlying the Viking sand in the Leduc area.

Correlation with Athabaska River Area, Alberta

The microfaunal assemblage from the basal Labiche shale of the Athabaska River area contains species similar to species from the Lower Shaftesbury microfauna (ref. 80, p. 12). The following paired species show marked similarities:

Lower Labiche Shale	Lower Shaftesbury formation
Reophax sp.	Reophax 31-211-B
Gaudryina sp.	Gaudryina 31-230-A
Verneuilina canadensis	Verneuilina 31-258-A

All forms from the Labiche shale listed above occur within ten feet of the top of the Pelican sand.

Several unfigured species from both faunal suites, examined by the writer, showed some similarity.

In addition to the above fauna Wickenden (ref. 80, p. 12) reports Miliammina c.f. manitobensis and an Ammobaculites sp. resembling Ammobaculites tyrrelli Nauss from the Lower Labiche Shale.

Conspecific forms occur in the Lower Shaftesbury microfaunal assemblage.

On the microfaunal evidence presented, the Lower Labiche Shale may be correlated with the Lower Shaftesbury formation.

Correlation with Imperial Eldorena Well #1

(L.s.d. 4, Sec. 27, Twp. 57, Rge. 20, W. of 4th)

The scarcity of published names for the microfaunas of Western Canada made it necessary for the writer to personally examine the suites from some Central Alberta well to utilize correlative information from unnamed forms. The Eldorena Well #1 was chosen because of immediate availability of microfaunal suites picked by Bullock.

A microfaunal assemblage with many elements common to the Lower Shaftesbury fauna occurs in the Lloydminster shale in Imperial Eldorena Well #1. The following paired species from the Eldorena well and the Lower Shaftesbury formation are identical or show strong similarity.

Eldorena Well #1	Lower Shaftesbury Formation
Reophax sp.	Reophax sp.
Hyperammina sp.	Hyperammina 31-280-A
Nodosinella sp.	Nodosinella 31-290-B
Tritaxia sp.	Tritaxia 31-274-A
Ammobaculites sp.	Ammobaculites 31-290-D
Ammobaculites fragmentaria	Ammobaculites fragmentaria
Gaudryina sp.	Gaudryina 31-258-B
Verneuilina sp.	Verneuilina 31-258-A
Verneuilina c.f. canadensis	Verneuilina 31-211-A
Trochammina	Trochammina sp.

All of the above species from the Eldorena Well occur sixteen feet above the top of the Viking sand except Nodosinella which occurs twenty-six feet above the Viking sand.

Especially diagnostic is the occurrence of Tritaxia 31-274-A and Nodosinella 31-290-B from the Lloydminster shale, these two species being characteristic of the Verneuilina-Gaudryina fauna of the Shaftesbury formation.

On the basis of the microfaunal evidence presented in this thesis, the writer presents the following correlation chart (fig. V):

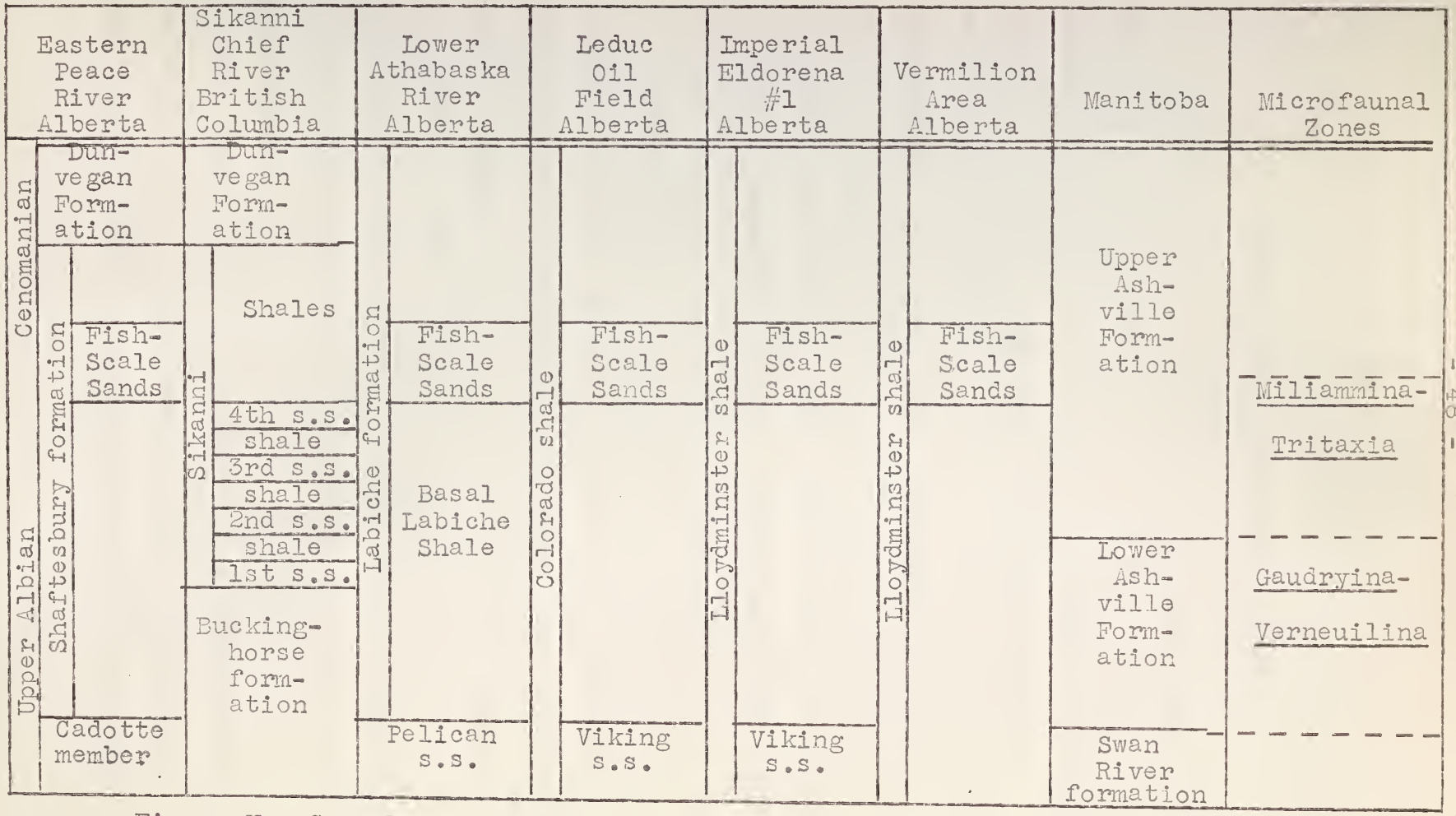


Figure V. Correlation Chart of the Shaftesbury Formation and its Correlatives

CHAPTER IV

FORMAL DESCRIPTION OF MICROFAUNA

The Shaftesbury formation foraminiferal suites are restricted almost entirely to arenaceous forms. The foraminiferal fauna of the Lower Cretaceous of Western Canada is proving to be quite different from any previously described from North America. The specimens described in this thesis are given species rank and where not comparable to already named species are designated by a number rather than a name to avoid the creation of manuscript names. These new species will be given names in the event of publication.

The species of foraminifera illustrated and described in this thesis represent only a portion of the species of foraminifera present in the Shaftesbury fauna. Several species of the Shaftesbury fauna are identical to some described by Stelck in his unpublished thesis. Most of these are not described in this thesis but reference is made to them in the discussion of the microfaunas. Of the remaining species in the Shaftesbury microfauna, those species which have the greatest stratigraphic significance have been selected for illustration and description.

The fauna is described in alphabetical sequence. The first two numbers of the species designation refers to the suite in which the hypotype was found. The stratigraphic position of this suite may be obtained from the appendix.

ORDER FORAMINIFERA

GENUS AMMOBACULITES CUSHMAN 1910

Ammobaculites 31-246-A

Plate 2, Figure 12

Test elongate, straight, early portion closely coiled, later portion in straight slightly expanding uniserial series, three chambers visible in coiled portion, three to five chambers in straight series, ultimate chamber rounded, pyriform. in shape; sutures indistinct in coiled portion, distinct and impressed in straight portion, at right angles to long axis of test in later chambers; wall arenaceous with grains about .04 mm. size embedded in much cement; aperture simple, terminal.

Length of hypotype - 0.74 mm., diameter of coiled portion - 0.10 mm., length of ultimate chamber - 0.24 mm., width of ultimate chamber - 0.20 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality

16-47-31; lower part of the Shaftesbury formation, 246' below middle gypsiferous sandstone (fish-scale zone).

Hypotype - University of Alberta Paleontological Type Collection

Remarks: This species is somewhat similar to Ammobaculites coprolithformis (Schwager) Cushman 1946, Plate 3, Fig. 8, but is smaller and has a pyriform shaped ultimate chamber. It shows some relationship to Ammobaculites humei Nauss 1947, from the Mannville formation but has a different wall structure. Ammobaculites 31-246-A has a smaller diameter and the wall is composed of smaller particles than Ammobaculites humei.

Ammobaculites 31-286-C

Plate 2, Figure 13

Test elongate, earlier portion coiled closely, later portion a straight, slightly expanding series of chambers; four chambers in coiled portion, six to eight chambers in uniserial portion, ultimate chamber drawn out to a short neck; sutures distinct, depressed, at right angles to long axis of test; wall finely arenaceous with considerable cement; aperture simple, terminal, at end of short neck.

Length of hypotype - 0.94 mm., diameter of coiled portion - 0.18 mm., length of ultimate chamber - 0.20 mm., width of ultimate chamber - 0.22 mm.

Hypotype locality: Smoky River, Alberta, twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 286' below middle gypsiferous sandstone (fish-scale zone).

Hypotype - University of Alberta Paleontological Type Collection

Remarks: This species shows a relationship with Ammobaculites fragmentaria but is not compressed, is finely arenaceous, and does not taper as much. It is also similar to Ammobaculites 31-290-D but the chambers on the former are shorter and the sutures are more thickened. Ammobaculites 31-286-C has a greater number of chambers than Ammobaculites tyrrelli Nauss.

Ammobaculites 31-290-D

Plate 2, Figure 11

Test elongate, earlier portion coiled closely with three chambers visible, later portion a straight series of four chambers; chambers about equal in size except for ultimate chamber which is larger and somewhat pyriform in shape: sutures distinct, at right angles

to long axis of test; wall finely arenaceous with considerable cement; aperture simple, terminal, at end of short neck.

Length of hypotype - 0.56 mm., diameter of coiled portion - 0.20 mm., length of ultimate chamber - 0.18 mm., width of ultimate chamber - 0.18 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 290' below middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is very similar to Ammobaculites tyrrelli Nauss, 1947, but differs in having one less chamber visible in coiled portion. This species is probably the immature form of Ammobaculites 31-286-C described above, as it occurs in the same suites. It is therefore considered conspecific with Ammobaculites 31-286-C.

Ammobaculites 32-20-A

Plate 2, Figure 14

Test elongate, earlier portion coiled closely in involute series of four chambers, later portion in a straight expanding uniserial series of seven to nine

chambers; chambers inflated, increasing in size as added, ultimate chamber drawn out to a short neck sutures distinct, depressed, at right angles to long axis of test; wall finely arenaceous with some cement; aperture simple, terminal, at end of short neck.

Length of hypotype - 1.06 mm., diameter of coiled portion - 0.16 mm., length of ultimate chamber - 0.22 mm., width of ultimate chamber - 0.20 mm.

Hypotype locality: Peace River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-32; from within basal 100' of the Shaftesbury formation.

Hypotype: University of Alberta Paleontological Type Collection

Remarks: this species is similar to Ammobaculites 31-286-C but the chambers are more globular, the initial coiled portion is smaller and the chambers are relatively longer. The wall structure is much finer than Ammobaculites 31-246-A.

The writer feels that this could well be the microspheric form of the species Ammobaculites 31-286-C but there is some indication that the

dominance of this form against the megalospheric form has a stratigraphic value, the indication being that Ammobaculites 32-20-A has a predominance in the earlier beds and Ammobaculites 31-286-C has a predominance somewhat higher. Whether this should constitute a basis for varietal difference is important only in statistical analyses of the foraminiferal populations.

GENUS GAUDRYINA D'ORBIGNY 1839

Gaudryina 31-230-A

Plate 2, Figures 6, 7

Test elongate, earlier and smaller portion triserial, later and larger portion biserial and twisted, tapering gradually away from apertural end in biserial portion, more rapidly in triserial portion, rounded in end view; chambers increasing in size as added in biserial portion, about three convolutions of three chambers each in triserial portion, about eight chambers in biserial portion; sutures distinct, slightly depressed; wall arenaceous with grains to .04 mm. in diameter with considerable cement as an exterior coating masking the outlines of the grains and giving the exterior a smooth, slightly

pustulate surface; aperture a notch at inner margin of last formed chamber; color brownish.

Length of hypotype - 0.84 mm., greatest width of biserial portion - 0.24 mm., length of triserial portion - 0.28 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-31; lower part of the Shaftesbury formation, 230' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species shows a strong similarity to Gaudryina hectori Nauss, 1947. The test is more rounded, the aperture is smaller and the triserial portion is relatively longer. This Gaudryina probably stands in varietal relationship with Gaudryina hectori.

Gaudryina 31-258-B

Plate 1, Figure 5

Test elongate, gradually tapering away from maximum width at penultimate chamber, earlier and smaller portion triserial, later portion biserial and slightly twisted; chambers gradually increasing

in size as added in biserial portion, chambers in biserial portion slightly inflated, four convolutions of three chambers each in triserial portion, six to eight chambers in biserial portion, sutures indistinct, slightly depressed; wall smooth, arenaceous with grains about .02 mm. in diameter with some brownish cement; aperture an elliptical notch at inner margin of last formed chamber; color brownish.

Length of hypotype - 0.52 mm., width at penultimate chamber - 0.21 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-31, lower part of the Shaftesbury formation, 258' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: this species is similar to Gaudryina 31-230-A in general shape of test and in relative proportions of triserial to biserial portion. It differs in being less elongate, possessing more globular chambers and in having a coarser wall structure. Gaudryina 31-258-B resembles Gaudryina hectori in shape of chambers and shape of aperture

but differs in being less elongate.

GENUS HAPLOPHRAGMOIDES CUSHMAN 1910

Haplophragmoides 31-286-B

Plate 1, Figures 16, 17

Test small, planispiral, involute; periphery broadly rounded; chambers distinct, inflated, subglobular, five to six in last whorl; sutures distinct, depressed, radial, straight; wall composed of finely arenaceous material with numerous grains up to .025 mm. in diameter, much cement; aperture an arched slit with slight lip at base of apertural face of last formed chamber; color white.

Diameter (major) of hypotype - 0.40 mm., diameter (minor) of hypotype - 0.35 mm., thickness of hypotype - 0.20 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 286' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is similar to

Haplophragmoides linki Nauss, 1947, but has fewer chambers and the sutures and umbilicus are less well defined.

Haplophragmoides 31-290-E

Plate 2, Figures 17, 18

Test small, planispiral, involute, some specimens unequally involute with ultimate three chambers often showing evolute development on one side only, periphery rounded, chambers distinct, triangular in side view, seven to eight in last whorl; sutures distinct, slightly thickened, depressed only in peripheral region, straight, radial; wall finely arenaceous with considerable cement; aperture a slit at the inner margin of the last formed chamber.

Diameter (major) of hypotype - 0.64 mm., diameter (minor) of hypotype - 0.62 mm., thickness of hypotype - 0.15 mm.

Most specimens of this species are deformed by flattening (Figure 17, Plate 2).

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-31 ; lower part of Shaftesbury formation, 290' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species bears a strong resemblance to Haplophragmoides rota Nauss, 1947, but has less chambers in the final whorl and the sutures are slightly thickened. It also shows a tendency toward being unequally involute and is relatively thicker.

Haplophragmoides linki Nauss (H. 32-14-A)

Plate 1, Figures 7, 8

Synonymy:

Haplophragmoides rugosa, Cushman, 1927, Royal Soc. Canada Trans., 3rd ser., vol. 21, sec. 4, p. 128, pl. 1, fig. 2.

Haplophragmoides linki, Nauss, 1947, Journal of Paleo., vol. 21, no. 4, p. 339, pl. 49, fig. 7a, 7b.

Test small, planispiral, involute, a tiny umbilicus, periphery narrowly rounded; chambers distinct, eight in last whorl, triangular in side view; sutures distinct, straight, radial, slightly depressed; wall finely arenaceous; aperture an arched slit at base of apertural face of last formed chamber.

Diameter of hypotype - 0.32 mm., thickness of hypotype - 0.10 mm.

Hypotype locality: Shaftesbury Settlement, Alberta, Twp. 83, Rge. 22, W. of 6th meridian, Alberta, locality 16-47-32; from within basal 100' of the Shaftesbury formation.

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is almost identical with Haplophragmoides linki Nauss, 1947, and the writer has no hesitation in assigning it to this species. It differs from Haplophragmoides linki in being more narrowly rounded in peripheral view but this may be due to flattening. This species of Haplophragmoides has some features similar to Haplophragmoides rugosa Cushman and Waters, 1926, but is smaller, has more distinct sutures and is much finer grained.

GENUS HYPERAMMINA H. B. BRADY 1878

Hyperammina 31-280-A

Plate 2, Figure 23

Test elongate with a closed proloculum and elongate, irregularly cylindrical second chamber; proloculum compressed, placed at an angle to second chamber, second chamber open at other end; wall

smooth, finely arenaceous with considerable white cement; aperture the opening of the end of the tubular chamber; color white.

Length of hypotype - 0.72 mm., width of hypotype - 0.14 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of the Shaftesbury formation, 290' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: The proloculum of this species is not bulbous as in Hyperammina elongata (Brady).

Frequently, the proloculum of the Hyperammina is broken off and the tubular portion may be differentiated from Bathysiphon by the irregularity of the tube which reaches a diameter of 0.28 mm.

GENUS MILIAMMINA HERON-ALLEN AND EARLAND, 1930

Miliammina 30-4-A

Plate 2, Figures 24, 25, 26

Test fusuline; chambers long and tubular, arranged in triloculine series, final tubular chamber very distinct, tapering toward aperture and projecting

above other chambers of test, three chambers visible from each side; sutures indistinct, depressed; wall finely arenaceous with considerable white cement; aperture a simple circular opening at tapered end of final chamber; color white.

Length of hypotype - 0.72 mm., width of hypotype - 0.30 mm., thickness of hypotype - 0.14 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-30; lower part of the Shaftesbury formation, 4' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This Miliammina resembles a Miliammina from the shale between the second and third Sikanni sandstones (Stelck - unpublished thesis) but the Shaftesbury specimen has more chambers. This species differs from Miliammina manitobensis in its triloculine arrangement as compared to the latter's quinqueloculine arrangement.

Miliammina 30-31-A

Plate 1, Figures 3, 4

Test elliptical, compressed; chambers each half a turn in length, added on opposite sides in a single plane, about six chambers visible on each side, only last two distinct, characterized by lighter color, in contrast to the dark appearance of the cement forming the sutures and partially obscuring the earlier chambers; sutures indistinct in earlier chambers and distinct in later chambers; wall finely arenaceous but coating of translucent cement obscuring individual grains; aperture is the opening of the last formed chamber; color tan.

Length of hypotype - 0.52 mm., width of hypotype - 0.30 mm., thickness of hypotype - 0.04 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-30; lower part of Shaftesbury formation, 31' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species of Miliammina is very similar in outer development to the calcareous genus

Massilina. This indicates that there is as great a diversity as between the genera of the Miliolids and undoubtedly it will be necessary to erect a new genus to receive these distinctive Shaftesbury forms.

Miliammina 30-129-A

Plate 1, Figures 17, 18

Test oval, compressed?, chambers distinct, triloculine, two visible on each side; sutures indistinct; wall finely arenaceous with much white cement; aperture open end of last formed chamber; color white.

Length of hypotype - 0.50 mm., width of hypotype - 0.27 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-30; lower part of Shaftesbury formation, 31' below middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection.

Miliammina 30-147-A

Plate 2, Figures 8, 9, 10

Test miliolid shaped; chambers elongate, tubular, twisted, each half a turn in length, triloculine in arrangement, three visible on one side, two on the other; sutures distinct, depressed; wall finely arenaceous with much white cement; aperture a slightly restricted opening at end of last formed chamber; color white.

Length of hypotype - 0.50 mm., width of hypotype - 0.34 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-30; lower part of Shaftesbury formation, 147' below middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is probably the unsquashed ancestral form of Miliammina 30-129-A below which it occurs stratigraphically.

Miliammina 31-286-A

Plate 2, Figures 15, 16

Test broadly elliptical, somewhat compressed; chambers distinct, tubular, almost as broad as long, in triloculine arrangement, three visible on each side; sutures distinct, depressed; walls smooth, finely arenaceous of clear grains with considerable white cement; aperture large, simple, the open unconstricted end of the last formed chamber, one side of aperture bounded by previous chamber; color white.

Length of hypotype - 0.64 mm., width of hypotype - 0.48 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of the Shaftesbury formation, 286' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Miliammina 32-14-B

Plate 2, Figures 19, 20, 21

Test elliptical, slightly compressed; chambers elongate, tubular, each half a turn in length, in quinqueloculine arrangement, three visible on one side, four on the other; sutures distinct, slightly depressed; wall finely arenaceous with considerable cement; aperture terminal, the open end of the last formed chamber that projects very slightly beyond the previous chambers; color light buff.

Length of hypotype - 0.70 mm., width of hypotype - 0.42 mm., thickness of hypotype - 0.16 mm.

Hypotype locality: Peace River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-32; from with basal 100' of Shaftesbury formation.

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species shows some relationship with Miliammina manitobensis Wickenden in the quinqueloculine arrangement of the chambers. It differs from Miliammina manitobensis in that it lacks the development of the neck and the noticeable constricted aperture. Whereas in Miliammina

manitobensis the shape of the chambers is that of an inverted L, the chambers of Miliammina 32-14-B are as a normal L with the aperture at the top end of the vertical bar. Miliammina 32-14-B resembles a Miliammina from the Buckinghorse formation, 290' below the top of the first Sikanni sandstone (Stelck unpublished thesis) in the arrangement of the chambers, in the distinct, depressed nature of the sutures and the smooth, dull finish of the surface. It differs from this form in its greater length, in the greater regularity of its chambers and finer grain of the wall.

GENUS NODOSINELLA H. B. BRADY 1876

Nodosinella 31-290-B

Plate 1, Figure 9

Test compact, tapering away from maximum width near apertural end, elliptical in cross-section; chambers arranged in straight uniserial pattern, five in number, earlier chambers indistinct, later chambers distinct, increasing in size as added, final chamber at least one-third the length of entire test; sutures obscure, at right angles to long axis of test; wall very finely arenaceous with much white

cement masking character of sand grains, smooth; aperture simple, rounded, terminal, 0.03 mm. in diameter; color white.

An unfigured paratype of the microspheric? stage shows a terminal chamber almost two-thirds of total length of specimen and a more pointed posterior outline than in the hypotype.

Length of hypotype - 0.49 mm., width of hypotype - 0.28 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of the Shaftesbury formation, 290' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: From the same suite from which the hypotype was collected, a specimen of Nodosinella is found similar in appearance to the specimen figured as Nodosinella glennensis Harlton , 1927, by Cushman, Plate 3, Figure 30. If these specimens are to be considered as conspecific with the hypotype there would be a strong indication of trimorphism in the species.

GENUS PROTEONINA WILLIAMSON 1858

Proteonina 30-142-A

Plate 2, Figure 3

Test a single elongate chamber with a slightly tapering neck sub-elliptical with sides parallel, neck tubular, short, set at slight angle to chamber; wall coarsely arenaceous, rough, composed of grains of 0.04 mm. in diameter with a moderate amount of translucent cement; aperture terminal, simple, at end of short neck.

Length of hypotype - 0.60 mm., width of hypotype - 0.32 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-30; lower part of the Shaftesbury formation, 142' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: The hypotype is somewhat flattened but there is a strong suggestion that it is a flattened cylindrical shape.

This species resembles Proteonina 31-290-A in wall structure but differs in shape of test.

Considerable similarity also exists with a Proteonina from the Buckinghorse formation, 279' below the top of the first Sikanni sandstone (Stelck unpublished thesis) but this species is larger and is composed of finer grains.

Proteonina 31-290-A

Plate 2, Figure 22

Test a single flask shaped chamber with a tubular neck, maximum width of test at two-thirds of length from aperture; wall of test is coarsely arenaceous, numerous large clear sand grains about 0.02 mm. in diameter interlocked with smaller sand grains and cemented with translucent cement; aperture is rounded, terminal at end of straight tubular neck.

Length of hypotype - 0.48 mm., width of hypotype - 0.34 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 290' below middle gypsiferous sandstone, (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is similar to a Proteonina from the Buckinghorse formation, 148' below the top of the first Sikanni sandstone (Stelck unpublished thesis) and a Proteonina from the Gastroplites zone of the Upper Fort St. John shales (Stelck unpublished thesis) but differs from both in being finer grained, in having a more rotund chamber and a shorter neck. It also resembles a Proteonina from the Buckinghorse formation, 304' below the top of the first Sikanni sandstone, in general shape, but differs in wall structure.

GENUS REOPHAX MONTFORT 1808

Reophax 31-194-A

Plate 2, Figure 2

Test elongate, uniserial, maximum width one third of length from apertural end, tapering toward either end; chambers three in number, inflated, increasing in size as added, final chamber much larger than previous two, drawn out to a short neck; sutures distinct, somewhat depressed; wall coarsely arenaceous, angular grains of about 0.04 mm. in diameter embedded in a matrix of translucent cement, apparent expression of grain size 0.02 mm. in diameter as only smaller angular surfaces show on surface flush with cement;

aperture simple, terminal.

Length of hypotype - 0.72 mm., width of hypotype - 0.38 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 194' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species resembles Reophax 31-211-B in general shape of test, number and arrangement of chambers, and in size. However, this Reophax is much more inflated and has a wall structure of embedded sand grains rather than studded sand grains. There is also some similarity with Reophax excentricus Cushman, 1910, but Reophax 31-194-A has one less chamber, is smaller and finer grained.

Reophax 31-211-B

Plate 2, Figure 1

Test elongate, uniserial, tapering toward either end from maximum width one third of distance from apertural end; chambers three in number, increasing in

size as added, final chamber forms largest part of test, drawn out to a short neck; sutures distinct, depressed; wall coarsely arenaceous with grains of about 0.04 mm. in diameter, grains partially embedded into moderate amount of translucent cement, surface rough; aperture simple, terminal at end of short neck.

Length of hypotype - 0.80 mm., width of hypotype - 0.44 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 211' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is identical with Proteonina? from the Buckinghorse formation, 130' below the top of the first Sikanni sandstone, (Stelck unpublished thesis). Stelck considered this form as the microspheric stage of a Proteonina which occurred stratigraphically lower. As no evidence in support of this was found in the Shaftesbury suites, and as the specimen has all the characteristics of a typical

Reophax, the specimen is assigned to this genus.

GENUS TRITAXIA REUSS 1860

Tritaxia manitobensis (30-26-A)

Plate 1, Figures 11, 12

Tritaxia manitobensis Wickenden, Royal Soc. Canada Trans., 3rd ser., vol. 26, sec. 4, p. 87, pl. 1, fig. 10, 1932.

Cushman, Cushman Lab. Foram. Research Special Publ. 7, p. 27, pl. 4, fig. 7, 1932.

Cushman, Upper Cretaceous Foram. of the Gulf Coast Region, etc., Geol. Surv. Prof. Paper 206, p. 31, pl. 7, fig. 8, 1946.

Test triserial, elongate, lobulate, tapering slightly at either end; chambers inflated, overlapping, ultimate chamber larger than earlier chambers, drawn out to a neck; sutures distinct, curved, depressed; walls smooth, finely arenaceous with considerable white cement; aperture terminal at end of neck of last formed chamber; color white.

Length of hypotype - 0.48 mm., width of hypotype - 0.23 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta,

locality 16-47-30; lower part of the Shaftesbury formation, 26' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is almost identical with Tritaxia manitobensis Wickenden but has a slightly shorter neck. The species from the Peace River region seems to have a more regular and smooth grain size.

Tritaxia 31-274-A

Plate 1, Figure 13, 14

Test rapidly expanding, triserial; chambers distinct, slightly inflated, four or five convolutions of three chambers each, last three chambers markedly larger than previous chambers; sutures distinct, depressed, curved; walls smooth, finely arenaceous, consisting predominantly of white cement; aperture subterminal, at the end of an incipient neck developed near the inner margin of the last formed chamber, the impression is gained in some specimens that the inner wall of the neck is broken down allowing for an apertural expression somewhat similar to that of Verneuilina; color white.

Length of hypotype - 0.63 mm., width of hypotype (widest part) - 0.46 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of the Shaftesbury formation, 274' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype - University of Alberta Paleontological Type Collection

Remarks: This striking species is previously undescribed but is known from above the Viking sand (Bullock unpublished thesis).

GENUS VERNEUILINA D'ORBIGNY 1840

Verneuilina 30-147-B

Plate 1, Figure 10

Test small, short, triserial, roughly triangular in section, edges abruptly rounded; chambers distinct, somewhat inflated, increasing in size as added, about fifteen in number; sutures distinct, slightly depressed; wall arenaceous, grains about 0.01 mm. in diameter, considerable white cement; aperture an elongate slit at inner margin of last formed chamber; color light buff.

Length of hypotype - 0.38 mm., width of hypotype - 0.21 mm.

Hypotype locality: Judah Station, Alberta, Twp. 82, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-30; lower part of the Shaftesbury formation, 147' below the middle gypsiferous sandstone (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is closely related to Verneuilina from the Gastroplites zone of the Upper Fort St. John shales (Stelck unpublished thesis), but is longer than that species and has more regular sutures.

Some relationship exists with Verneuilina cummingensis Nauss 1947, but the test expands more rapidly.

Verneuilina 31-211-A

Plate 2, Figure 4, 5

Test triserial, elongate, roundly triangular in section; chambers sub-globular, distinct, gradually increasing in size as added, arranged in three prominent vertical columns, twenty to twenty-seven in

number; sutures distinct, depressed, considerably thickened; wall finely arenaceous with considerable cement; aperture an elliptical opening at inner margin of last formed chamber.

Length of hypotype - 0.66 mm., width of hypotype - 0.30 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 211' below the middle gypsiferous sandstone horizon (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species resembles Verneuilina canadensis Cushman in having three prominent vertical series of inflated chambers but differs in having a much finer grain. Coarse grained varieties of the same species occur in the same suites. Verneuilina 31-211-A is also similar to a Verneuilina found in the Buckinghorse formation 266' below the top of the first Sikanni sandstone (Stelck unpublished thesis) but test shows greater expansion at terminal end.

Verneuilina? 31-246-B

Plate 1, Figures 1, 2

Test small, triserial in early portion, quadriserial in later portion, tapering, greatest width near apertural end, roughly quadrangular in end view, edges rounded; chambers numerous, sixteen in quadriserial portion, distinct, globular, gradually increasing in size as added, chambers indistinct in triserial portion, not more than eight in number; sutures distinct in quadriserial portion, slightly depressed; wall finely arenaceous with much cement, grains about 0.02 mm. in diameter; aperture a semicircular opening at the inner margin of the last formed chamber; color brownish.

Length of hypotype - 0.42 mm., width of hypotype - 0.18 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of the Shaftesbury formation, 246' below the middle gypsiferous sandstone horizon (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species, as well as the following one, Verneuilina 31-258-A, are not true Verneuilinas as the chambers become quadriserial in the later portion. This quadriserial arrangement could easily arise from twisting of a triserial Verneuilina. They are placed in the genus Verneuilina until a new genus can be erected to include them. These Verneuilinas bear some resemblance to the genus Arenobulimina Cushman, 1927, in having the early portion triserial in arrangement. However, Arenobulimina has the later chambers arranged in a spiral rather than in a quadriserial arrangement and typically has an aperture with a broad rounded tooth.

This species is related to Verneuilina 31-258-A as it is triserial in early portion and quadriserial in later portion. However, the chambers are more numerous, are less distinct and there is less cement.

Verneuilina 31-246-B is also similar to a Verneuilina from the Buckinghorse formation, 227' below the top of the first Sikanni sandstone (Stelck unpublished thesis).

Verneuilina? 31-258-A

Plate 1, Figure 6

Test small, tapering rapidly away from apertural end, triserial in early portion, quadriserial in later portion; chambers slightly inflated, distinct, nine in triserial portion, twelve in quadriserial portion; sutures distinct, slightly depressed and thickened; wall finely arenaceous with much translucent cement; aperture in hypotype indistinct, in paratypes a semi-circular opening at inner margin of last formed chamber; color brownish.

Length of hypotype - 0.44 mm., width of hypotype - 0.22 mm.

Hypotype locality: Smoky River, Alberta, Twp. 83, Rge. 22, W. of the 6th meridian, Alberta, locality 16-47-31; lower part of Shaftesbury formation, 258' below the middle gypsiferous sandstone horizon (fish-scale zone).

Hypotype: University of Alberta Paleontological Type Collection

Remarks: This species is almost identical to Verneuilina found in the Buckinghorse formation, 304' below the top of the first Sikanni sandstone.

Explanation of PLATE I

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Figure 1, 2: Verneuilina 31-246-B, x95, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; 1, re-touched photograph of side view 2, sketch of end view 81

Figure 3, 4: Miliammina 30-31-A, x95, hypotype, from lower part of Shaftesbury formation, Smoky River below Judah, Alberta; 3, sketch of edge view. 4, photograph of side view 64

Figure 5: Gaudryina 31-258-B, x95, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; partially re-drawn photograph of side view 56

Figure 6: Verneuilina 31-258-A, x95, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; partially re-drawn photograph of side view . 82

Figure 7, 8: Haplophragmoides 32-14-A, x95, hypotype, from lower part of Shaftesbury formation, Peace River upstream from forks, Alberta; 7, re-touched photograph of side view. 8, sketch of apertural view 60

Figure 9: Nodosinella 31-290-B, x95, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; slightly re-touched photograph of side view. 69

Figure 10: Verneuilina 30-147-B, x95, hypotype, from lower part of Shaftesbury formation, Smoky River below Judah, Alberta; re-touched photograph of side view 78

Figure 11, 12: Tritaxia 30-26-A, x95, hypotype, from lower part of Shaftesbury formation, Smoky River below Judah, Alberta; 11, slightly re-touched photograph of side view. 12, slightly re-touched photograph of other side 76

Explanation of PLATE I (Continued)

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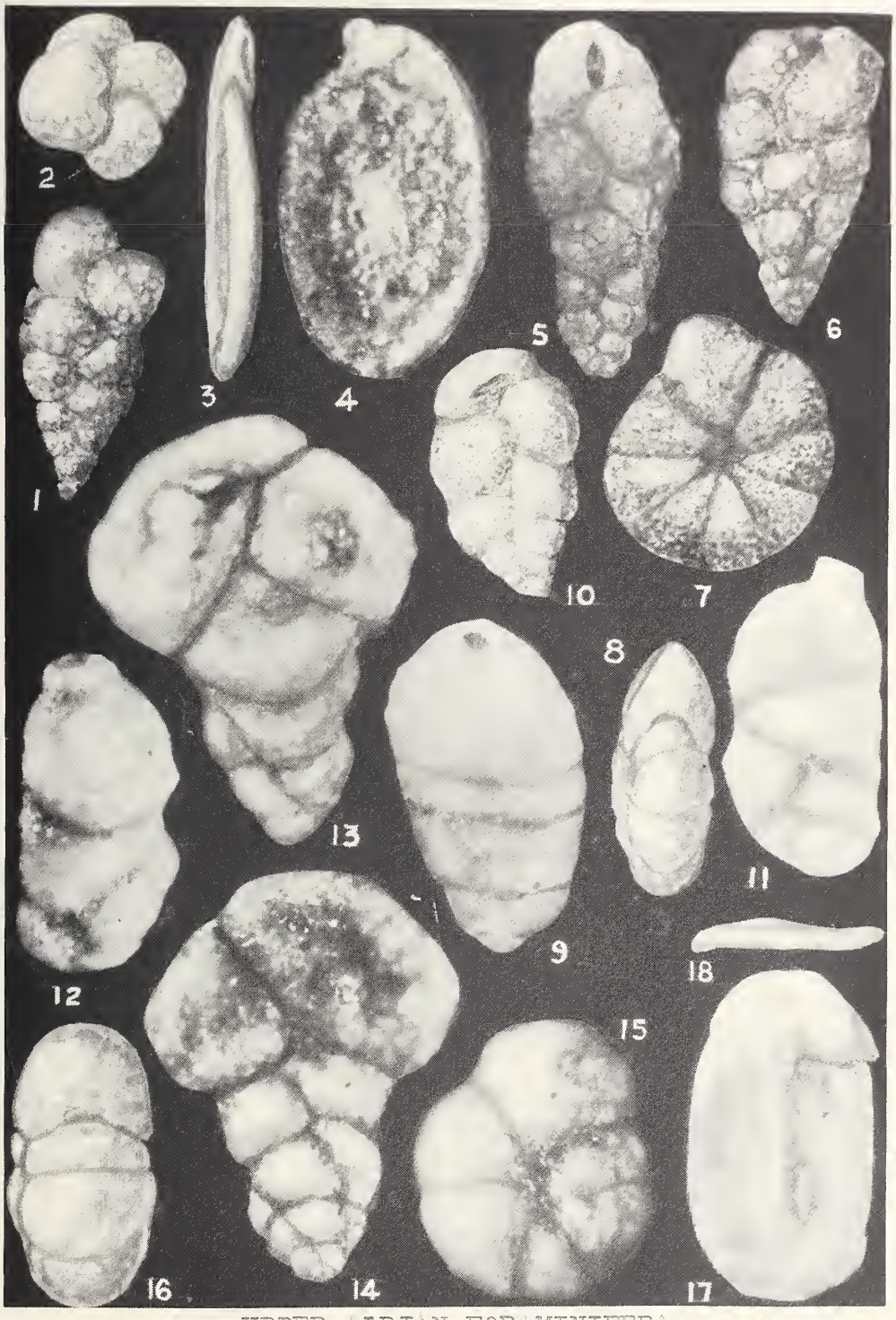
Figure 13, 14: Tritaxia 31-274-A, x95, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; 13, slightly re-touched photograph of side view. 14, slightly re-touched photograph of other side 77

Figure 15, 16: Haplophragmoides 31-286-B, x95, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; 15, slightly re-touched photograph of side view. 16, sketch of apertural view 58

Figure 17, 18: Miliammina 30-129-A, x95, hypotype, from lower part of Shaftesbury formation, Smoky River below Judah, Alberta; 17, slightly re-touched photograph of side view. 18, sketch of end view . . . 65

PLATE I



UPPER ALBIAN FORAMINIFERA
LOWER SHAFTESBURY FORMATION
x95

Explanation of PLATE II

Page

Figure 1: Reophax 31-211-B, x45, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; re-touched photograph of side view 74

Figure 2: Reophax 31-194-A, x45, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; photograph of side view, grain patterns sketched 73

Figure 3: Proteonina 30-142-A, x45, hypotype, from lower part of Shaftesbury formation, Smoky River below Judah, Alberta; slightly re-touched photograph of side view 71

Figure 4, 5: Verneuilina 31-211-A, x45, hypotype, from lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; 4, partially re-drawn photograph of side view. 5, sketch of end view 79

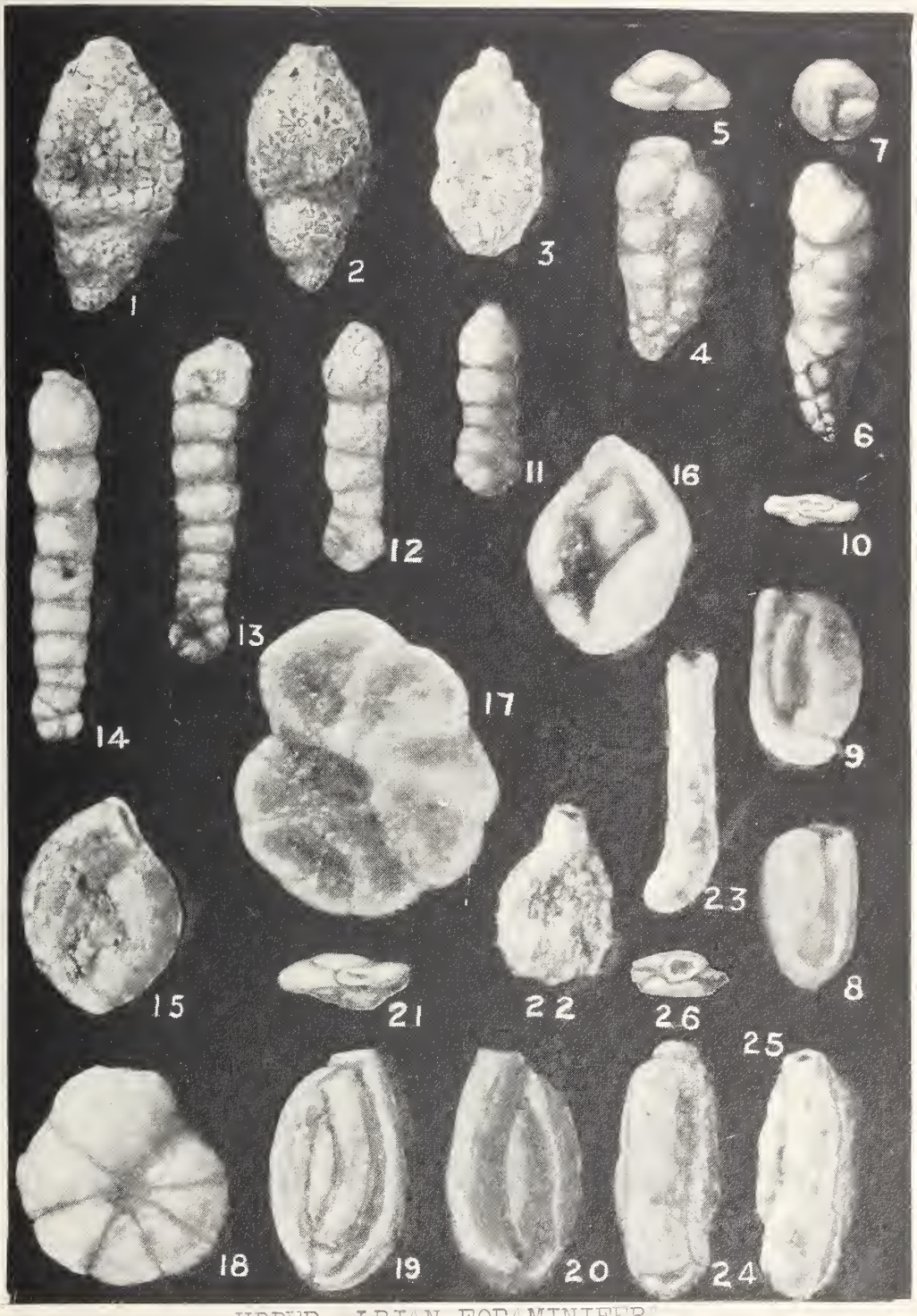
Figure 6, 7: Gaudryina 31-230-A, x45, hypotype, lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta; 6, re-touched photograph of side view. 7, sketch of end view 55

Figure 8, 9, 10: Miliammina 30-147-A, x45, hypotype, from lower part of Shaftesbury formation, Smoky River below Judah, Alberta; 8, slightly re-touched photograph of side view of paratype. 9, slightly re-touched photograph of other side of hypotype. 10, sketch of end view of hypotype 66

Figure 11: Ammobaculites 31-290-D, x45, hypotype, lower part of Shaftesbury formation, Smoky River downstream from Judah, Alberta, slightly re-touched photograph of side view 52

Explanation of PLATE II (Continued)

Explanation of PLATE II (Continued)



UPPER ALBIAN FORAMINIFERA
LOWER SHAFTESBURY FORMATION
x45

APPENDIX

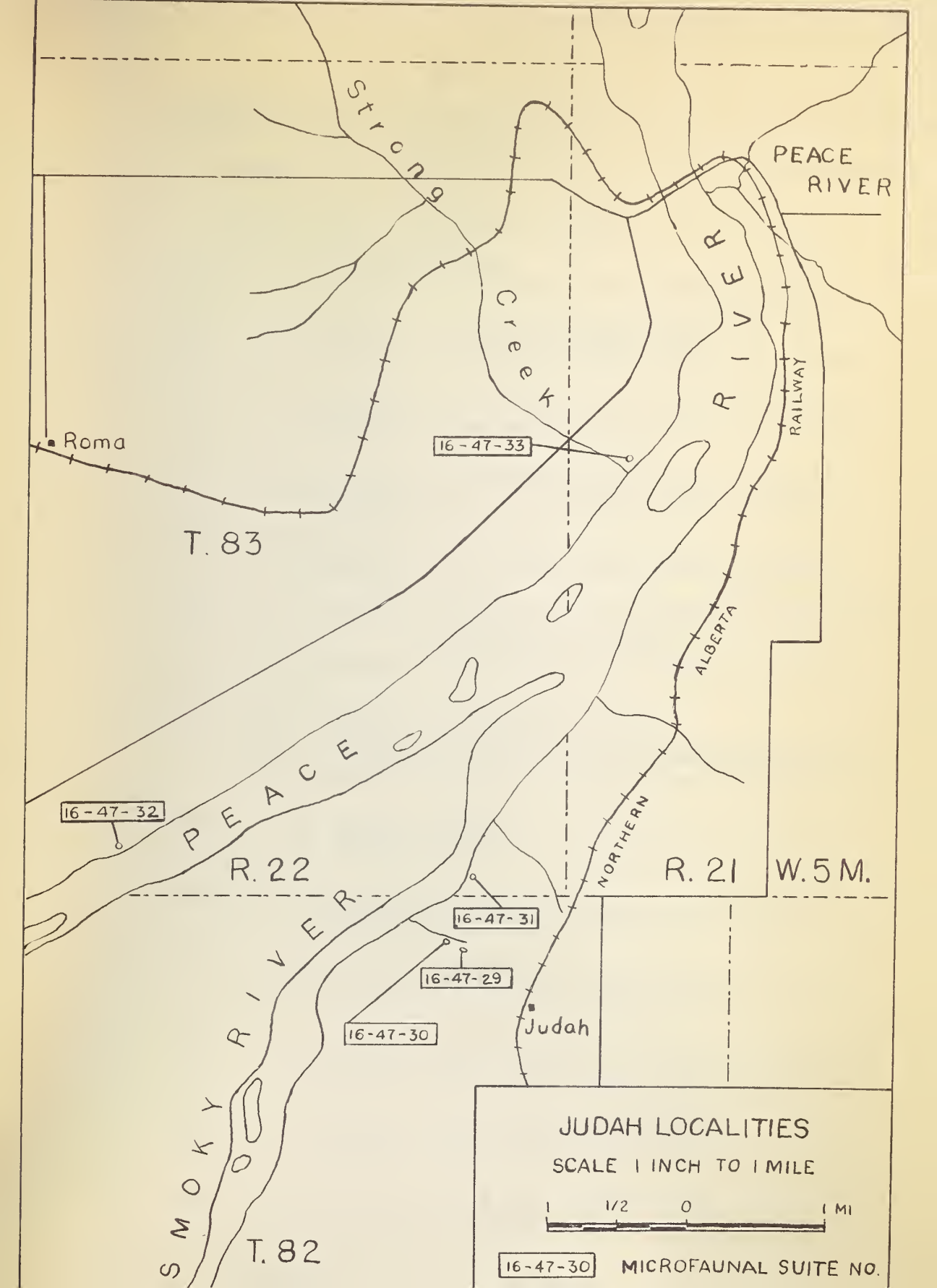
LOCALITY INDEX OF FORAMINIFERAL SUITES

The Cretaceous section in the eastern Peace River area is as follows: (Ref. 2 (a), Appendix)

Wapiti s.s. and sh.	1,100'
Smoky River sh.	850'-900'
Dunvegan s.s.	520'
Shaftesbury formation	640'
Peace River formation	380'
Loon River sh.	682'-800'
"McMurray" sands	25'-160'

The foraminiferal collections were made from sediments of the Shaftesbury formation and the upper part of the Peace River formation. Two unsampled intervals occur in this section. A gap of 25'-50' occurs in the lower part of the formation. The upper 150' (approximately) of the Shaftesbury formation is also unsampled. A sandstone band in a fish-scale zone, occurring approximately 250' below the base of the Dunvegan formation and 350'-400' above the top of the Peace River formation is used as a marker horizon.

The lithologic succession of the strata from which the foraminiferal suites were obtained is as follows:


Strong Creek
PEACE RIVER
PEACE RIVER
RAILWAY
Roma
16-47-33
T. 83
ALBERTA
NORTHERN
16-47-32
PEACE
R. 22
R. 21
W. 5 M.
16-47-31
16-47-29
16-47-30
Judah
SMOKY RIVER
T. 82
JUDAH LOCALITIES
SCALE 1 INCH TO 1 MILE
1
1/2
0
1 MI
16-47-30
MICROFAUNAL SUITE NO.

LOCALITY 16-47-29 Shaftesbury formation above the middle gypsiferous sandstone horizon (fish-scale horizon) below Judah station, Alberta.

--- Boulder clay
--- Suite 16-47-29-115 from top of below.

6' --- Shale, slightly silty, soft
--- Suite 16-47-29-109 from base of above.

5' --- Shale, as above
--- Suite 16-47-29-104 from base of above.

5' --- Shale, as above
--- Suite 16-47-29-99 from base of above.

5' --- Shale, as above
--- Suite 16-47-29-94 from base of above.

5' --- Shale, slightly silty with ½" ferruginous siltstone at base
--- Suite 16-47-29-89 from base of above.

5' --- Shale, slightly silty
3" --- Ironstone, nodules 3"x8"
9" --- Shale, slightly silty with Pickeringite
--- Suite 16-47-29-83 from base of above.

5' --- Shale, silty
--- Suite 16-47-29-78 from base of above.

5' --- Shale, silty
--- Suite 16-47-29-73 from base of above.

7' --- Shale, silty
--- Suite 16-47-29-66 from base of above.

2' --- Shale, silty
4' --- Shale, very silty
--- Suite 16-47-29-60 from base of above.

6' --- Shale, very silty, laminated
--- Suite 16-47-29-54 from base of above.

5' --- Shale, brownish, very silty, laminated
--- Suite 16-47-29-49 from base of above.

6' --- Shale, brownish, very silty laminated with fish-scales
--- Suite 16-47-29-43 from base of above.

6' --- Shale, as above (L281)
--- Suite 16-47-29-37 from base of above.

5' --- Shale, as above
--- Suite 16-47-29-32 from base of above.

5' --- Shale, as above
--- Suite 16-47-29-27 from base of above.

5' --- Shale, brownish, very silty, laminated, with fish-scales
--- Suite 16-47-29-22 from base of above.

6' --- Shale, as above
--- Suite 16-47-29-16 from base of above.

6' ---- Shale, as above
--- Suite 16-47-29-10 from base of above.

6' --- Shale, as above
--- Suite 16-47-29-4 from base of above.

1' 6" --- Shale, as above
3' --- Siltstone, with fish-scales, L280
1" --- Sandstone, gypsiferous with many fish remains (L282)
--- Top of locality 16-47-30 section

LOCALITY 16-47-30 Shaftesbury formation below the middle gypsiferous sandstone horizon (fish-scale horizon) below Judah station, Alberta

1" --- Sandstone, gypsiferous with many fish remains. This sandstone is base of 16-47-29 locality section.
1' --- Siltstone, argillaceous with fish-scales (L283)
3' --- Shale, very silty
--- Suite 16-47-30-4 from base of above.

6' --- Shale, very silty
--- Suite 16-47-30-10 from base of above.

5' --- Shale, very silty
--- Suite 16-47-30-15 from base of above.

6' --- Shale, silty, brown
--- Suite 16-47-30-21 from base of above.

5' --- Shale, silty, brown
--- Suite 16-47-30-26 from base of above.

5' --- Shale, silty
--- Suite 16-47-30-31 from base of above.

5' --- Shale, silty
--- Suite 16-47-30-36 from base of above.

4' --- Shale, silty
--- Suite 16-47-30-40 from base of above.

5' --- Shale, silty
--- Suite 16-47-30-45 from base of above.

8' --- Covered (silty shale)
--- Suite 16-47-30-53 from base of above.

8' --- Shale, silty
--- Suite 16-47-30-61 from base of above.

7' --- Shale, silty
--- Suite 16-47-30-68 from base of above.

5' --- Shale, silty
--- Suite 16-47-30-73 from base of above.

6' --- Shale, silty
--- Suite 16-47-30-79 from base of above.

6' --- Shale, silty
--- Suite 16-47-30-85 from base of above.

1' --- Shale, silty with sand lenses to $\frac{1}{2}$"
4' 10" --- Shale, silty (covered in part)
2" --- Ironstone
--- Suite 16-47-30-91 from top of below.

6' --- Shale, silty
--- Suite 16-47-30-97 from base of above.

5' --- Shale, silty
--- Suite 16-47-30-102 from base of above.

24' --- (Covered) shales
3' --- Shale, silty
--- Suite 16-47-30-129 from base of above.

5' --- Shale, silty
4" --- Ironstone silty
8" --- Shale, very silty
--- Suite 16-47-30-135 from base of above.

7' --- Shale, silty, with siltstone streaks at top
--- Suite 16-47-30-142 from base of above.

5' --- Shale, silty
--- Suite 16-47-30-147 from base of above.
--- Mud flow, covering.

LOCALITY 16-47-31 Shaftesbury formation below the middle gypsiferous sandstone horizon (fish-scale zone) half-mile downstream from Judah station, Smoky river, Alberta.

--- Sandstone, gypsiferous, stratigraphic horizon of top of locality 16-47-30 section

1' --- Sandstone, fine with siltstones, fish-scales
110' 10" --- Shales, etc. (calculated interval by correlation of individual beds from non-sampled locality $\frac{1}{4}$ mile south).
10" --- Sandstone, fine cross-bedded with 30% shale
1' 2" --- Shale, silty
3" --- Ironstone
3' 2" --- Shale, very silty
--- Suite 16-47-31-116 from base of above.

7' --- Shale, very silty
--- Suite 16-47-31-123 from base of above.

6' --- Shale, very silty
--- Suite 16-47-31-129 from base of above.

1' --- Shale, very silty
3" --- Ironstone, silty soft
5' 9" --- Shale, silty
--- Suite 16-47-31-136 from base of above.

4' 9" --- Shale, silty
3" --- Siltstone, with ironstone concretions
1' --- Shale, very silty
--- Suite 16-47-31-142 from base of above.

6' --- Shale, very silty
--- Suite 16-47-31-148 from base of above.

6' --- Shale, silty
3" --- Siltstone, with ironstone concretions
2' 3" --- Shale, silty
--- Suite 16-47-31-156 from base of above.

6' --- Shale, silty
--- Suite 16-47-31-162 from base of above.

6' --- Shale, silty
--- Suite 16-47-31-168 from base of above.

5' --- Shale, silty laminated
4" --- Sandstone, fine soft, ferruginous (L284)
2' 6" --- Shale, silty
--- Suite 16-47-31-176 from base of above.

6' --- Shale, slightly silty
--- Suite 16-47-31-182 from base of above.

6' --- Shale, slightly silty
--- Suite 16-47-31-188 from base of above.

6' --- Shale, slightly silty
--- Suite 16-47-31-194 from base of above.

6' --- Shale, slightly silty
--- Suite 16-47-31-200 from base of above.

6' --- Shale, very slightly silty
--- Suite 16-47-31-206 from base of above.

5' --- Shale, slightly silty
--- Suite 16-47-31-211 from base of above.

7' --- Shale, slightly silty
--- Suite 16-47-31-218 from base of above.

6' --- Shale, slightly silty
--- Suite 16-47-31-224 from base of above.

6' --- Shale, slightly silty
--- Suite 16-47-31-230 from base of above.

4" --- Ironstone, double band. This horizon is 230' 7" below the middle gypsiferous sandstone horizon by measurement at a locality ¼ mile to the south

6' 10" --- Shales, silty
--- Suite 16-47-31-236 from 2' above base of above.

4" --- Ironstone

2' 8" --- Shale, silty
--- Suite 16-47-31-241 from base of above.

5' --- Shale, silty
--- Suite 16-47-31-246 from base of above.

5' --- Shale, slightly silty
--- Suite 16-47-31-251 from base of above.

7' --- Shale, silty
--- Suite 16-47-31-258 from base of above.

4' 6" --- Shale, silty

3" --- Ironstone, nodules 3" x 5"

1' 3" --- Shale, silty
--- Suite 16-47-31-264 from base of above.

4' --- Shale, silty

6" --- Ironstone, silty

1' --- Shale, silty
--- Suite 16-47-31-269 from base of above.

4' 6" --- Shale, silty
--- Suite 16-47-31-274 from top of below.

4' --- Shale, slightly silty, soft
5" --- Ironstone, nodules 5" x 2'
1' 7" --- Shale, very slightly silty
--- Suite 16-47-31-280 from base of above.

6' --- Shale, very slightly silty
--- Suite 16-47-31-286 from base of above.

4' --- Shale, as above
--- Suite 16-47-31-290 from top of below

2' 6" --- Shale, as above
6" --- Ironstone
21' --- Covered
--- Waters edge, Smoky river

LOCALITY 16-47-32 - Shaftesbury shales near base of formation at Shaftesbury settlement, Alberta.

--- Gravels, river flats
--- Suite 16-47-32-0 from top of below.

4' --- Shale, silty
2" --- Siltstone ferruginous
1' --- Shale, silty
--- Suite 16-47-32-5 from base of above.

4' --- Shale, silty
--- Suite 16-47-32-9 from base of above.

5' --- Shale, silty
2" --- Ironstone, silty
--- Suite 16-47-32-14 from top of below.

6' --- Shale, silty
8" --- Ironstone, nodules 8" x 3' at 4' centres
--- Suite 16-47-32-20 from top of below.

--- Concealed interval 30' to 80'
--- Suite 16-47-35-50 from base of above.

LOCALITY 16-47-33, basal Shaftesbury shales and upper Peace River formation, junction of Smoky and Peace rivers, north bank, Alberta.

--- Gravels
1' --- Shale
--- Suite 16-47-33-64 from base of above.

5' --- Shale
--- Suite 16-47-33-59 from base of above.

5' --- Shales, brown silty with fish remains
--- Suite 16-47-33-54 from base of above.

3' --- Shales, brown silty with fish remains
1' 3"--- Sand, fine thinly bedded with cone-in-cone development
11"--- Shale, grey with fish remains
--- Suite 16-47-33-49 from base of above

1' 1"--- Sandstone, soft, coarse with shale streaks
4' --- Shale, dark grey, silty, light colored at top
--- Suite 16-47-33-44 from base of above.

--- Contact Shaftesbury/Peace River formation.

14' 6"--- Sandstone, medium with three sets of foreset beds in upper 5 feet (L289)
2' 2"--- Sand, unconsolidated (L288)
--- Suite 16-47-33-27 from top of below.

3' 10"---Shale, light grey green with sand at top
1"---Shale, coaly
8' --- Sandstone, fine with carbonaceous shale and coaly fragments
10' --- Sandstone, cross-bedded, medium grained salt and pepper appearance (L287)
5' --- Sandstone, irregular bedded with shaly partings and carbonaceous streaks
6"--- Sandstone, medium fine grained, rusty carrying Inoceramus cadottensis.
4' --- Sandstone, medium fine, with jet (L286)
--- Waters edge, Peace river.

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